The
ENGINEERS' DIGEST

A World Review of
DESIGN & PRODUCTION · RESEARCH & DEVELOPMENT

VOL. XXI No. 5 MAY, 1960

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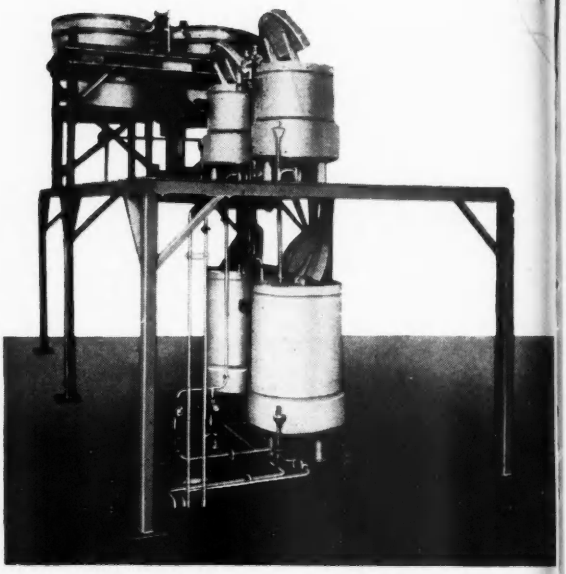

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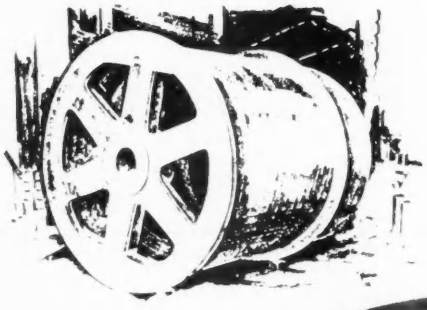

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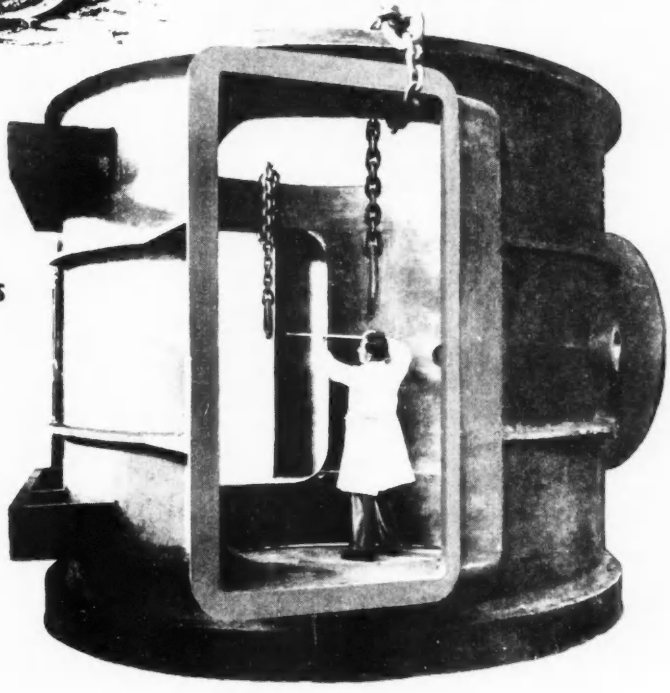

A 13½ ton evaporator casing cast in high duty iron.

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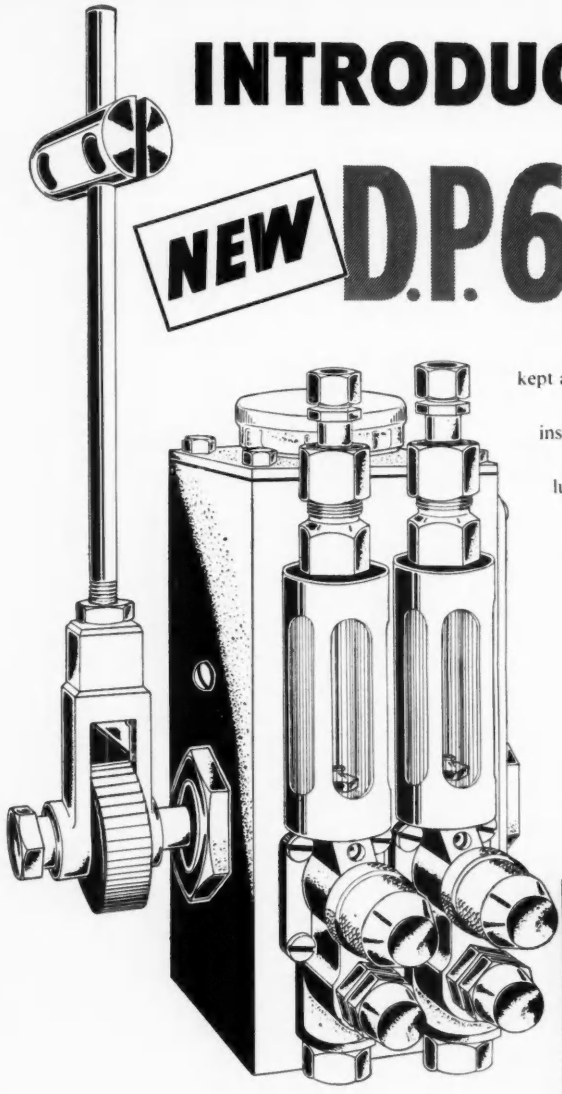

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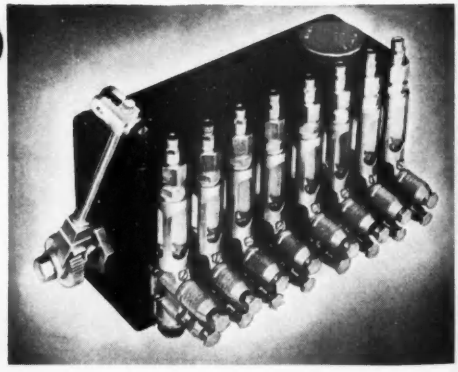

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The ENGINEERS' DIGEST

A World Review of DESIGN & PRODUCTION · RESEARCH & DEVELOPMENT

VOL. XXI No. 5 MAY, 1960

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Annual Subscription Rates:
£2 2s. 0d. in the Sterling area, $7.50 in the Dollar area

Printed in Gt. Britain by THE ALCUIN PRESS, Welwyn Garden City, Hertfordshire, and published monthly by the proprietors, ENGINEERS' DIGEST LTD., 120 Wigmore Street, London, W.1.

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The MINIDIGEST

A brief note in *Product Engineering* (April 11, 1960) mentions that, following the reported development of fuel elements for nuclear reactors, in which glass fibres are used as fuel carriers, with the uranium dioxide incorporated into the glass during its manufacture, **fuel elements using metal fibres** are now being developed by the Nuclear Division of the Martin Co. In these elements, the fibres are of molybdenum and are incorporated into a uranium dioxide ceramic composition, swaged to rods with a density of about 90%. As distinct from the glass fibres, which have no function in heat removal, the metal fibres improve thermal conductivity and assist heat removal. Thus, the addition of 15% by volume of molybdenum improves thermal conductivity by 30% at room temperature and even more at elevated temperatures.

* * *

Details are given in *Vestnik Mashinostroyeniya* for February 1960 of recent Russian experiments in connection with an **improved method of heating forging blanks in salt baths**—a method which hitherto has not been satisfactory, owing to the detrimental effects of the salt films which appear on the surfaces of workpieces after heating. In tests with the new process, forging blanks for turbine blades, made of a high-alloy steel, were first preheated in a box-type furnace to 600°C and then immersed in a bath of molten barium chloride at 1250°C, after which they were plunged into water for from 2 to 3 sec, their temperature falling by only 20 to 25°C. The entire operation took from about 7 to 10 min, whereas comparative tests on similar blanks, using conventional methods, took about four times as long. With the new process, the blanks had smooth and clean surfaces, completely free from salt films, and, in addition, scale formation did not exceed 0·25%, as compared with a value of from about 1·1 to 1·6% with conventional methods.

* * *

It is reported (*Machine Design*, March 17, 1960) that a high-voltage electron accelerator has been installed in the Diamond Research Laboratory of De Beers Consolidated Mines Ltd. for studying the **effects of radiation on the physical properties of diamonds.** Because of their conductivity properties, diamonds are already known to have potential applications in electronics. Thus, certain types are semiconductors

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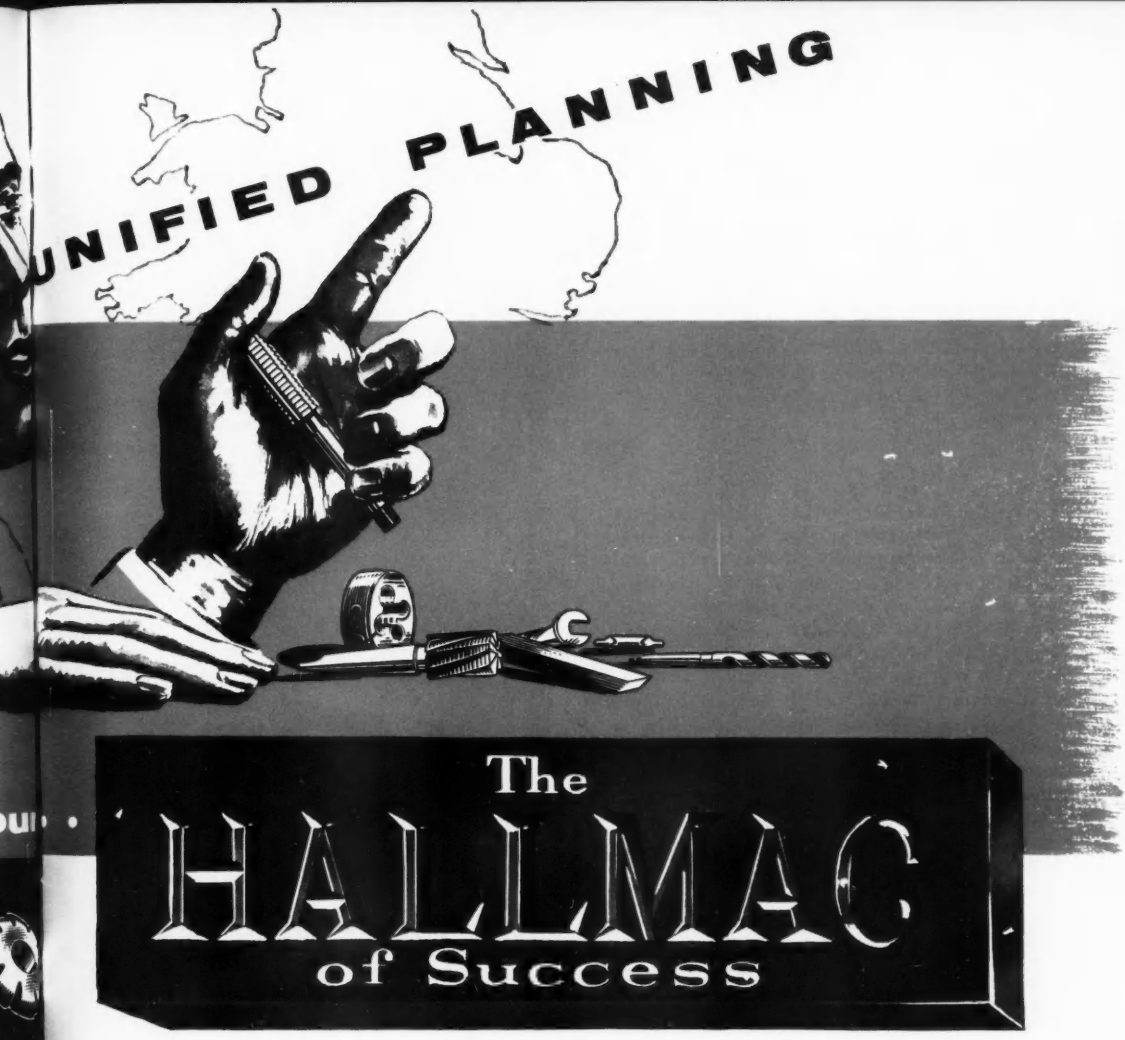

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The MINIDIGEST

and their electrical resistance varies considerably with temperature, so much so that they are capable of registering immediately temperature variations as little as 0·05°C. Semiconductive diamonds could also be used as efficient point-contact transistors, with the special advantage that they can be subjected to large temperature variations without incurring any damage or loss of efficiency.

* * *

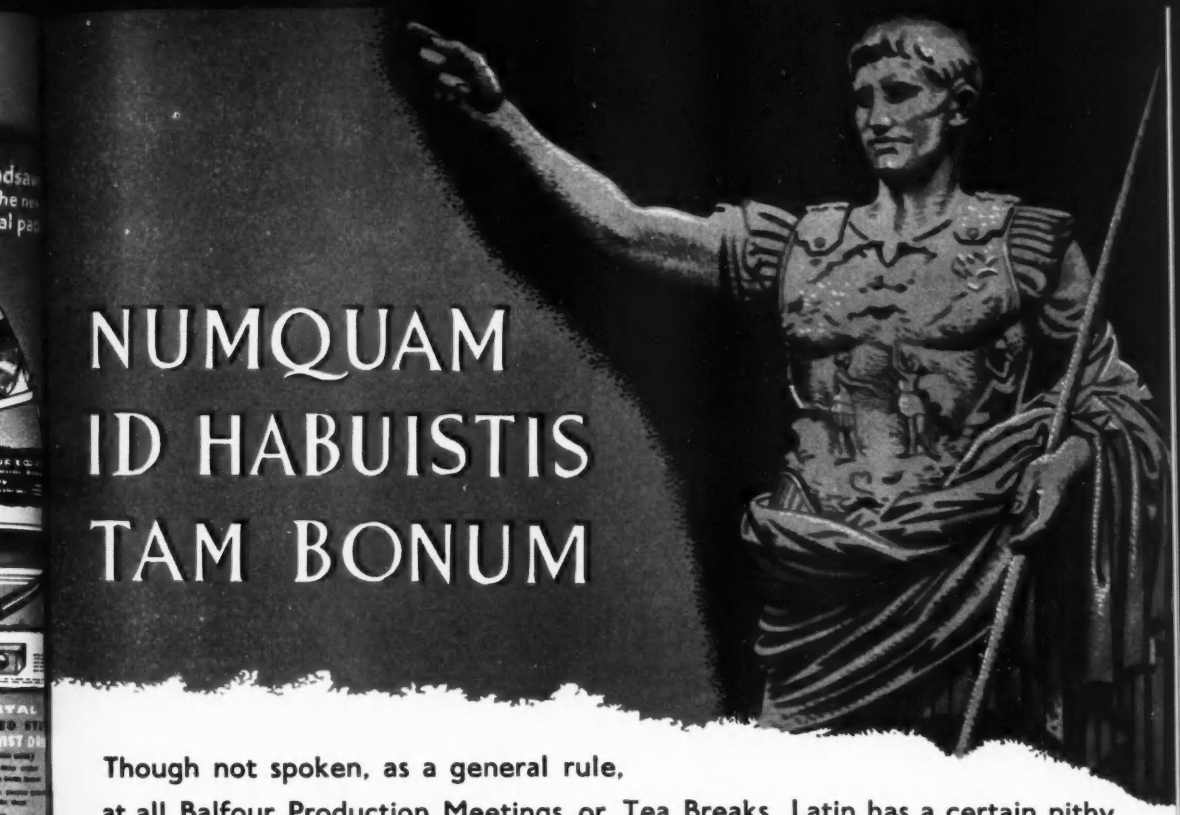
A recent article in the Czechoslovak journal *Elektrotechnicky Obzor* (April 1960) analyses the merits of the **construction of large hydro-alternator stator frames in concrete**—a method of construction which appears to be specially attractive in circumstances where the stator frames are so large that they cannot be transported by rail. It is pointed out, however, that, although a slight reduction (0·7 to 1%) of the total cost can be achieved by replacing a conventional welded-steel stator frame by a concrete structure, the time required for construction and installation is about twice as long. Furthermore, the use of concrete tends to make adjustment of the air gap more difficult, and is liable to cause an increase in maintenance and repair costs.

* * *

By replacing the normal thermionic valves with a miniature solid-state device designated a trinistor, the Westinghouse Electric Corporation are now producing **ultrasonic generators** which are claimed to be 50% more efficient and more reliable than equipment at present available. The trinistor makes it possible to use standard 120-V, 60-cps power, converting the line frequency to between 18,000 and 22,000 cps for driving the ultrasonic transducer and, at the same time, reducing the weight of the generator by as much as 80% and its overall size by about 50%.

* * *

As reported in *Materials in Design Engineering* for April 1960, a **new high temperature epoxy resin formulation,** developed in the U.S.A. by the Brunswick-Balke-Collender Co., appears to have successfully overcome two major drawbacks of existing epoxy laminating resins, i.e., their unsatisfactory performance in the 500°F temperature range, and the difficulty of adapting high-temperature epoxy resins to low-pressure vacuum-bag or filament-winding production



NUMQUAM ID HABUISTIS TAM BONUM

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at all Balfour Production Meetings or Tea Breaks, Latin has a certain pithy elegance when it comes to summing up a situation.

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techniques. The new resin, which is based on a diepoxide derived from peracetic acid, is stated to have excellent handling characteristics, while its wettability and viscosity are such that several plies can be laid down and impregnated at once, as distinct from the standard procedure of impregnating one ply at a time. In addition, it has a long pot life, and the resin system is highly functional and is therefore capable of a high degree of cross-linking. Postcuring the resin at temperatures below 500°F produces a translucent material with excellent electrical proties.

* * *

Details of a series of tests carried out at the Israeli Institute of Technology, Haifa, in connection with the **effects of alkaline media on the corrosion of mild steel in reinforced concrete** are reported in the *Bulletin of the Research Council of Israel* (December 1959). In these tests, mild-steel specimens, 6 mm in diameter and 80 mm in length, were immersed in solutions of calcium hydroxide, with and without the addition of solutions containing sodium chloride, including seawater, cement mortar made with seawater, and mixtures of sodium hydroxide and sodium chloride. It was found that, in the absence of these compounds, corrosion gradually decreases with increasing pH-value, until inhibition finally takes place. When these compounds are present, small concentrations tend to intensify corrosion, while high concentrations tend to have a restraining effect.

* * *

In the issue for March 1960 of *Mashinostroitel*, it is reported that **failures of the pressure chambers of several Russian diecasting machines** after 30 to 40 casting operations were mainly due to the welding of hot metal pieces to the chamber wall or to the plunger. It is also stated that existing methods of dealing with this problem by lubricating the pressure chamber have not been satisfactory, as they reduce productivity and increase gas absorption and hence the porosity of the castings produced. It is now claimed, however, that these difficulties, which are particularly pronounced when casting steel and hard alloys, have been overcome by means of a graphite sleeve inserted into the body of the chamber. With this arrangement, it is reported that the useful life of the chamber has been increased by a factor of from 4 to 5, and that lubrication of the chamber walls is completely unnecessary.

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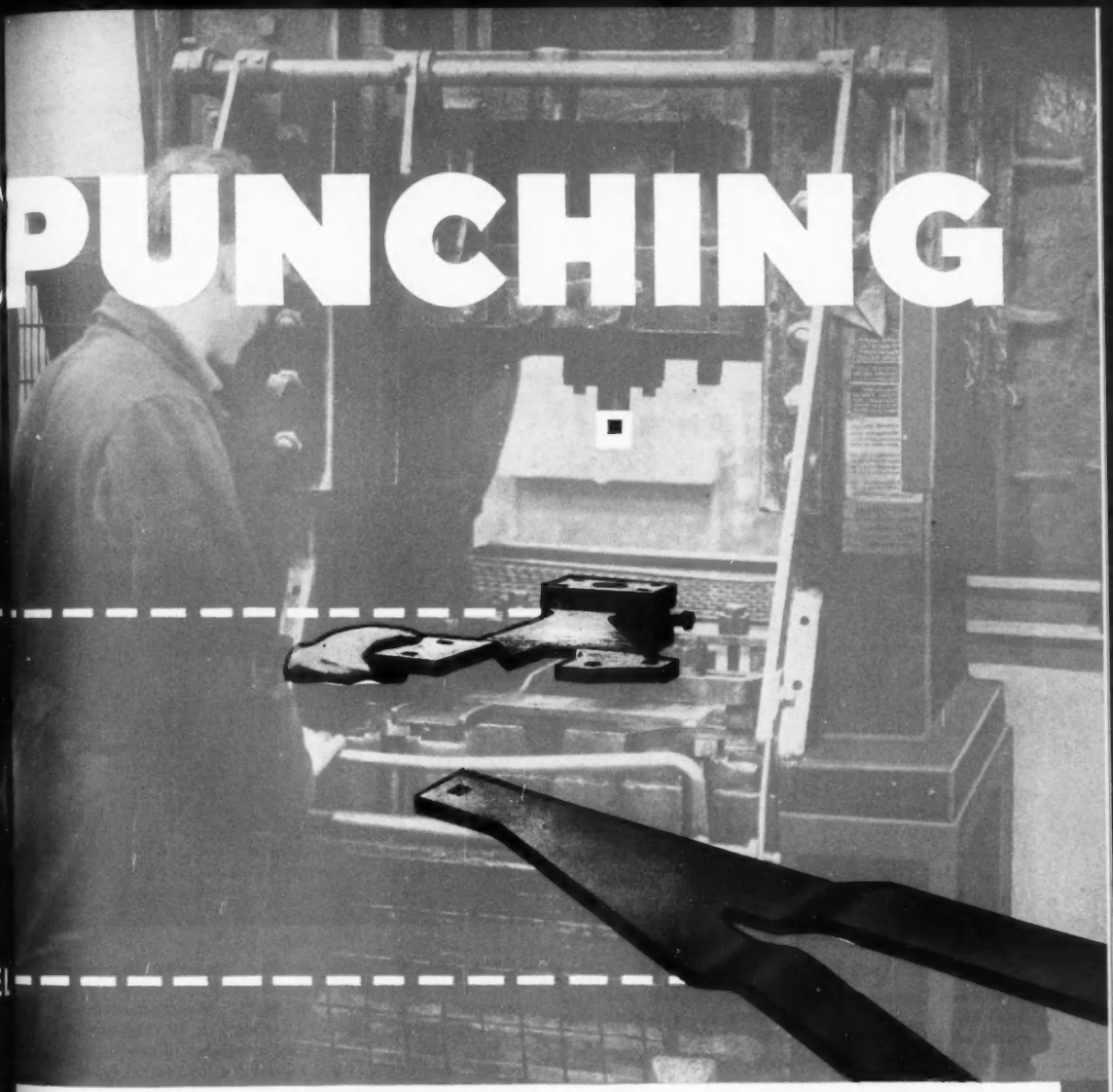

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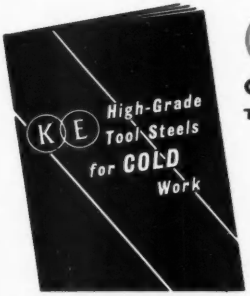

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PERSONAL

The Newage Group announce the appointment of **Mr. A. D. MacKay** as managing director of Newage Engineers Limited and to the boards of the subsidiary companies, consisting of Newage (Manchester) Limited, Arthur Lyon & Co. (Engineers) Limited, H. E. Nunn & Company Limited, Newage Machine Tools Limited, and Newage Industries Inc., U.S.A. **Mr. S. J. Harris** will hold the office of executive chairman of the Newage Group and will continue as managing director of the subsidiary companies. Mr. MacKay will be located at Manchester.

* * *

Mr. W. Pigdon, who has been for the past nine years general manager of the Wells factory of E.M.I. Electronics Ltd., will shortly be taking up a new appointment as executive vice-president of E.M.I.-Cossor Electronics Ltd., in Halifax, Nova Scotia, Canada. Mr. Pigdon's duties at Wells will be taken over by **Mr. E. Bagley** as chief executive responsible to **Mr. P. A. Allaway**, deputy managing director of E.M.I. Electronics.

* * *

It is announced by Perkins Engines Ltd. that **Mr. F. H. Shepheard** has been appointed manager of their Spanish, Portuguese, and South American export-sales zone. **Mr. R. F. Mead, F.C.A.,** has been appointed comptroller of the Perkins Group, relinquishing his appointment as chief accountant, this position being taken over by **Mr. P. Brealey, B.Sc.(Econ.), A.C.A.,** formerly assistant chief accountant. **Mr. R. Gore, M.I.Mech.E., A.M.I.P.E.,** has been appointed to the newly created post of facilities manager of F. Perkins Ltd., of Peterborough, and will be responsible for planning, plant, tool-room operations, industrial engineering, and safety.

* * *

Venner Limited, of New Malden, Surrey, announce that **Mr. E. Tauchert, M.I.Mech.E., F.B.H.I.,** has been elected chairman, but will continue as managing director of the company and its subsidiaries.

* * *

Mr. E. F. D. Webb, B.Sc.(Eng.), A.C.G.I., has been appointed engineering manager of Hagan Controls Limited.

* * *

It is announced that **Mr. T. D. H. Andrews,** at present director and general manager, has now been appointed managing director of Dowty Nucleonics Limited. **Mr. Mr. D. G. A. Thomas,** the chief engineer, has been elected a director of the company.

* * *

Mr. W. G. Bryce, B.Sc.(Eng.), A.M.I.Mech.E., A.M.I.E.E., formerly industrial consultant to the National Union of Manufacturers Advisory Service, has been appointed general manager of Heyes & Co. Ltd., the manufacturing electrical engineers, of Wigan, Lancashire.

The Fairey Company Ltd. announce the appointment of **Mr. L. R. E. Appleton, O.B.E., M.A., M.I.Mech.E., F.R.Ae.S.,** as managing director of Fairey Engineering Ltd., and of **Mr. P. J. Duncton, B.Sc., A.R.C.S., D.I.C., A.F.R.Ae.S., F.Inst.Ph.** (who is already a director of Fairey Engineering) as general manager of the Heston factory, which is now the head office of Fairey Engineering Ltd. **Mr. H. G. Gregory, M.I.Prod.E.,** remains director and general manager of Fairey Engineering's Stockport factory.

* * *

It is announced that **Mr. E. J. Hudson** has been appointed divisional manager of the General Services Division of the Plessey Company Limited, Swindon Region.

* * *

Mr. J. R. Cotterill, J.P., M.I.E.E., M.I.Mech.E., M.I.Mar.E., M.A.I.E.E., has been appointed manager of the outside services department at the Witton works of the General Electric Co. Ltd , a newly formed department to co-ordinate the erecting, commissioning, and post-commission servicing of electrical plant.

* * *

Microcell Limited announce the appointment of **Mr. W. A. Bartlett** to their board as an executive director.

* * *

Mr. R. S. H. Shepard, M.C., T.D., F.C.A., and **Mr. L. B. Devins** have been appointed joint managing directors of the Sheffield Wire Rope Co. Ltd., a member of the Firth Cleveland Group. Mr. Shepard was formerly a director of the company, while Mr. Devins was an executive director and its general manager. **Mr. G. Liley** has been appointed to the board of British Lead Mills Ltd., also a member of the Firth Cleveland Group. Mr. Liley was formerly an executive director of the company.

* * *

Mr. W. N. Collins, assistant managing director of F. Perkins Ltd., has been elected chairman of the marine section of the Society of Motor Manufacturers and Traders, in succession to **Lt.-Cmdr. J. W. Thornycroft, C.B.E.** Mr. Collins has been a member of the Society's council and management committee for several years.

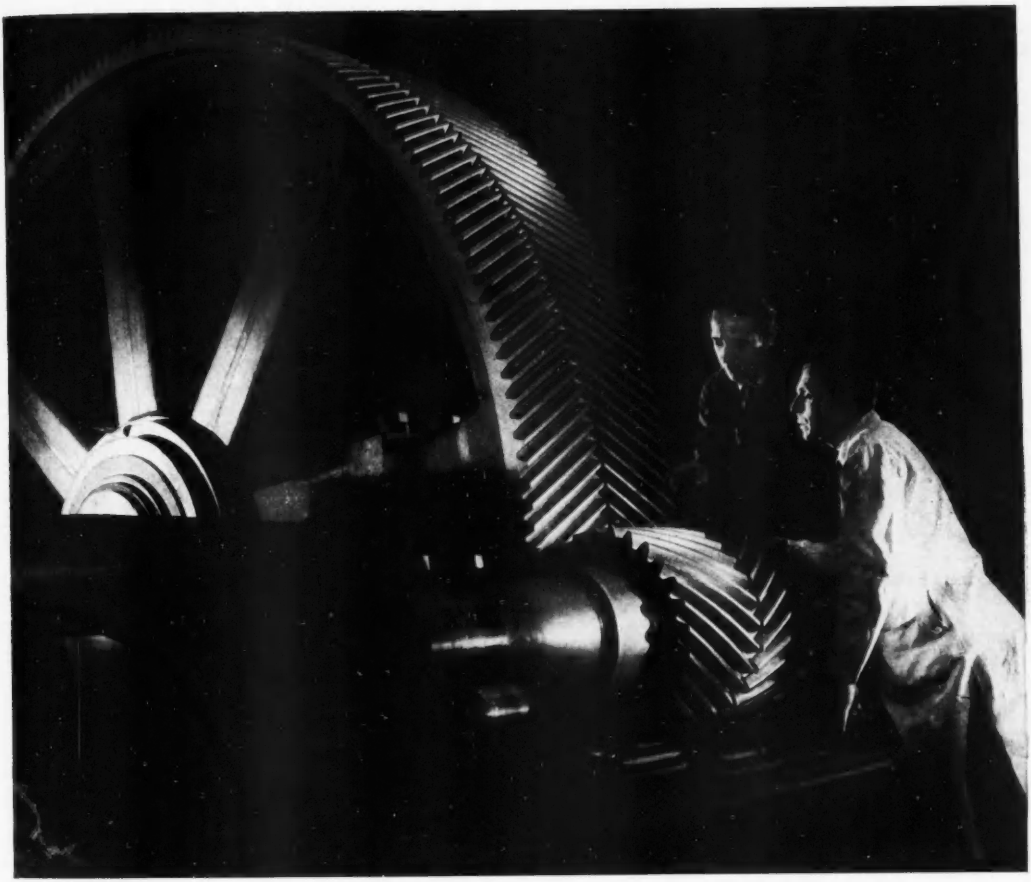
* * *

Following the enlargement of the company's sales organization, headed by **Mr. C. H. Noton,** commercial executive director, **Mr. J. H. Thorp** has been appointed sales manager of Semiconductors Ltd.

* * *

MR. GEORGE WOOD

We announce with deep regret the recent death of Mr. George Wood, C.B.E., vice-president of Thos. W. Ward Limited, of Sheffield. Mr. Wood became a director of the company in 1923 and assistant managing director in 1928, and, during his 57 years of active participation in the affairs of the Ward Group, was chairman or managing director of several subsidiary companies, but relinquished most of these appointments during the last few years.



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BUSINESS NOTES

The entire share capital of the **Anchor Insulating Co. Ltd.,** steam and refrigerating engineers, caulkers, etc., of Thermal Works, Woolwich Industrial Estate, London, S.E.18, has been acquired by **Thos. W. Ward Ltd.** The business of the Anchor Insulating Co. Ltd. is complementary to that of **Dick's Asbestos and Insulating Co. Ltd.,** a member company of the Ward Group, and a close working association will be developed between these two companies, with a view to furthering operations in the field of insulation.

* * *

The London sales office of **Klaxon Ltd.,** manufacturers of fractional-horsepower motors, industrial hooters, sirens, and flashing indicators for the commercial-motor industry, is now located at 189–191 Drummond Street, London, N.W.1 (Tel: EUSton 4102 and 4143).

* * *

The exclusive agreement between **Andrew Fraser & Company Limited** and **Deri (Engineers) Limited** has now terminated. As a result, the Deri-Sine range of hydraulic pumps and motors, etc., is now obtainable either from **Denison-Deri Limited,** of 342 Brighton Road, Shoreham-by-Sea, Sussex, an associate company of Deri (Engineers) Limited, or from Andrew Fraser & Company Limited, 64/65 Vincent Square, London, S.W.1.

* * *

It is announced by **Microcell Ltd.** that its Rubberized Hair Division has been formed into a subsidiary company, known as **Rubberized Hair Ltd.,** with works at 9–11 Curtain Road, London, E.C.2.

* * *

Edward G. Herbert Ltd., of Levenshulme, Manchester 19, have been appointed sole agents in Great Britain and Eire for the complete range of " Ellettrorava " balancing machines and equipment made by **Ing. A. Rava,** of Turin, Italy. This new agency is complementary to the existing arrangement with the **Tinius Olsen Testing Machine Co.**, who have themselves become the sole agents for Rava balancing equipment in the U.S.A. As a result, Edward G. Herbert Ltd. are now in a position to supply a comprehensive range of Olsen and Elettrorava balancing machines covering components from about 1 oz to 10 tons in weight.

* * *

It is announced by **Hagan Controls Limited,** a member company of **The Plessey Group,** that their address is now 14 Grosvenor Place, London, S.W.1. (Tel: BELgravia 6382).

* * *

In order to augment its existing electronics interests, the **Simms Motor & Electronics Corporation Limited** announce that it has acquired for cash the whole of the issued capital of **Cawkell Research & Electronics Limited,** of Scotts Road, Southall, Middlesex. The staff of the latter company will remain unchanged, and Mr. A. E. Cawkell will continue as director and general manager.

It is announced by the **Owen Organisation** that **Nuts & Bolts (Darlaston) Ltd.** have recently acquired control of **J. Stanley & Co. Ltd.,** of Kings Hill, Wednesbury, who will continue to trade under this name and who will operate as a subsidiary of Nuts & Bolts (Darlaston) Ltd. The directors of the new company are Mr. A. G. B. Owen (chairman), and Messrs. E. W. B. Owen, T. H. Foster, and T. Smith.

* * *

A licence and manufacturing agreement has been concluded between **Établissements Robert Messian,** of Paris and Cambrai, and Mr. Thomas Hindmarch, for the manufacture in France of Hindmarch/MWD marine transmissions. These transmissions are made in England by **Modern Wheel Drive Limited,** of Chesham and Slough, Bucks.

* * *

Pantak Limited, of Vale Road, Windsor, Berks., have concluded an agreement with **Sierex Limited,** of 241 Tottenham Court Road, London, W.1, for the marketing and servicing of the Siemens 15-MeV industrial betatron, which is a fully mobile unit capable of examining steel thicknesses up to 16 in.

* * *

Bouëllat Engineering Limited, of Bondway House, Bondway, London, S.W.8, announce that the name of the company has now been changed to the **Vauxhall Boiler Company Limited.** It is stated that this change is one of convenience, and does not involve a change in the company's structure.

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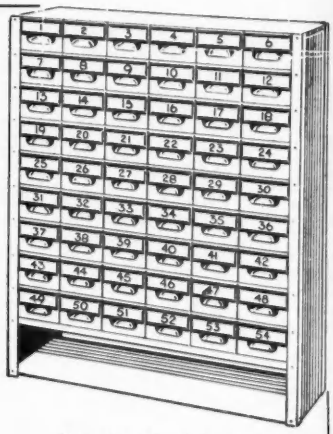

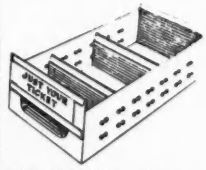

Contains 54 of these drawers, each 5" wide 3" high 11¼" long. 54 dividers and 54 drawer cards with each unit. Extra dividers 6d. each.

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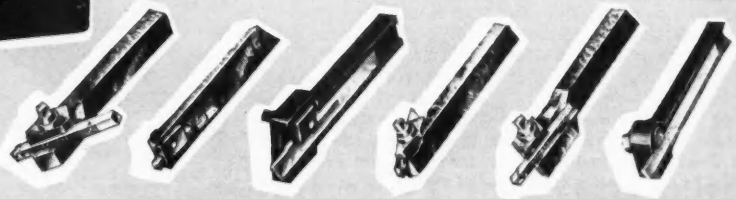
Cutting off tool holders—$\frac{3}{16}$"; $\frac{1}{8}$" to $\frac{1}{4}$" width, $\frac{11}{16}$" to $\frac{7}{8}$" width, 1" to 1$\frac{1}{4}$" width.

Eclipse



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'Eclipse' hacksaw blades and other tools are made by James Neill & Co. (Sheffield) Ltd. and are obtainable from all tool distributors.

UTH 3.

CONTRACTS

Head Wrightson Iron and Steel Works Engineering Ltd., a subsidiary of Head Wrightson & Co. Ltd., of Thornaby-on-Tees, announce the receipt of an order from the Skinningrove Iron Co. Ltd., for the design and construction of a materials-handling and iron-ore sintering plant at their works at Carlin How, N. Yorks. The plant is designed to produce ultimately 7000 tons per week of self-fluxing blast-furnace sinter from a mixture of imported and home ore fines. The total value of the work involved approaches £700,000. The present order follows the contract recently placed with Head Wrightson for a similar but somewhat larger plant at the Clyde Iron Works of Colvilles Ltd.

* * *

Two member companies of the Power-Gas Group, i.e., Ashmore, Benson, Pease & Co. Africa (Pty.) Ltd., of Johannesburg, South Africa, and P. G. Engineering Ltd., of Stockton-on-Tees, are to carry out an order valued at over £1,000,000 for the Rhodesia Broken Hill Development Company Limited. The order is for a zinc and lead I.V. furnace which will be installed at Broken Hill, Northern Rhodesia, and the contract includes the engineering, procurement, and construction of the whole of the plant within the furnace area, covering foundations, plant, and equipment. Process design is being supplied by Imperial Smelting Processes Ltd. and, on completion at the end of 1961, the plant will be one of the first four operating in the world. The new contract will be engineered in Salisbury, Rhodesia, in close collaboration with the client's consulting engineers, The Anglo-American Corporation of South Africa Limited.

* * *

Two major contracts, totalling about £650,000, have recently been awarded to Chemical Construction (G.B.) Limited by the newly formed Albatros Sulphuric Acid and Chemical Works, at Vlaardingen, Holland, this new company being jointly owned by Albatros Superfosfaatfabrieken N.V., of Utrecht, a member of the Royal Dutch Salt Group, and by the Cyprus Mines Corporation, of Los Angeles, Cal. The projects involve a very large complex sulphuric acid contact plant, designed to take gaseous sulphur dioxide from pyrites and from a Chemico plant of special design which decomposes 56% sulphuric acid refinery sludge coming from the adjacent Shell refinery.

* * *

Two orders for V.H.F. radio-communication equipment have been received by Plessey International Ltd., of Ilford, Essex, one from Canada and the other from South Africa. The Canadian order, valued at nearly $5,000,000, has been obtained from the Canadian government and is believed to be by far the largest single order ever received from an overseas country for British V.H.F. radio-communication equipment, which, in this case, will be used by the Canadian army. Incidentally, a substantial order for similar equipment was received last year by Plessey for the Australian army.

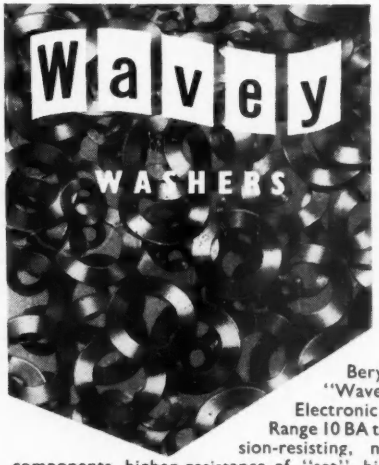
The second order, valued at £180,000, was received from the South African High Commissioner in London and is intended for use by the armoured fighting forces of the Union of South Africa. Identical equipment was recently ordered for South African fighting ships and will be installed in the near future.

* * *

The Incandescent Heat Co. Ltd., of Smethwick, has been awarded a major contract for the new Spencer steelworks of Richard Thomas & Baldwins Ltd. at Llanwern, near Newport, Mon. The contract is for coil-annealing plant with an output of 16,500 tons per week, i.e., nearly 100 tons per hour, of 60-in.-wide strip. In all, thirty furnaces will be supplied, of single and four-stack designs, together with furnace bases, forced-cooling hoods, and other ancillary equipment, these furnaces being the well-known Incandescent radiant-bowl-fired type. The complete contract, which is worth more than £1,250,000, is believed to be the largest single order for steel-sheet annealing plant ever placed in Great Britain. The new steelworks is scheduled to commence operations in October 1961.

* * *

The Steel Company of Wales have awarded Simon-Carves Ltd. a contract for gas-cleaning plant on two 400-ton open-hearth furnaces which are being installed at Port Talbot, the contract including the provision of equipment for dust conveying and disposal. Three 3-zone electro-precipitators to deal with about 140,000 cfm from the oxygen-processed furnaces will recover the dust in a dry state, and the resulting stack emission will be not more than 0·04 grain per cubic foot.



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NEWS ROUND-UP

Nuclear-Reactor Flux-Scanning Equipment

Used to measure the neutron-flux distribution through a nuclear reactor in the vertical and horizontal axes, the reactor flux-scanning equipment supplied to Atomic Power Constructions Ltd. by Elliott Nucleonics Ltd., a member of the Elliott-Automation Group, for the Trawsfynydd nuclear power station employs a system which follows the method used at Calder Hall.

In this system, a tungsten wire is irradiated for about 30 min after being inserted into one of the vertical channels in the reactor. It differs, however, from the Calder Hall method in that it is a semi-permanently installed device which permits measurement of the activity of the wire to take place in the sealed standpipe and obviates the handling, shielding, and sealing problems inherent in the earlier system, where the wire has to be removed in order to count the activity. The flux-scanning head is designed to be interchangeable with the control-rod mechanisms and uses the same standpipe closure and seal plug. At Trawsfynydd, a two-wire system will be used, so that the wires can be used alternatively. This is necessary, since it takes about a week for the activity of the irradiated wire to decay to less than 1%, when it can be used again. With the two-wire system, the period of waiting is reduced to three or four days.

Two identical winding units are used in each flux-scanning head, each comprising a winding drum driven by an a.c. induction motor, and including limit and signalling switches operated by gear-trains and cams. The winding drums are 2 ft in circumference and approximately 1¾ in. in width, and are helically grooved to accommodate 80 ft of the tungsten wire. A shielding-block separates the winding units from the ionization chamber above, and the wire passes through the shielding-block, taking a zig-zag course to prevent any radiation from below reaching the chamber. The ionization chamber is of the conventional coaxial cylindrical type, with three cylindrical electrodes, the intermediate electrode serving as the collector. The ionization chamber, which, in common with the rest of the flux-scanning head equipment, is of Elliott design, is suitable for operation in CO_2 at 150°C.

Effluent and Water-Treatment Exhibition

The First Effluent and Water Treatment Exhibition is to be held at the Seymour Hall, London, W.1, on October 18 to 21, 1960, and it is expected that a wide range of equipment, plant, and techniques will be exhibited and illustrated covering this important field. Simultaneously, a convention will be held with the co-operation of a number of societies and institutions specializing in effluent and water-treatment problems, at which papers will be given by leading experts. There will be opportunities for full discussion, and it is anticipated that the technology of water and trade-waste treatment will be advanced as a result of the increased public and industrial attention which will result.

The convention subjects will include analysis techniques, biological effluent treatment, boiler feed-waters, composting treatment, development of filtration and water-treatment plant, discussion of the Armour Com-

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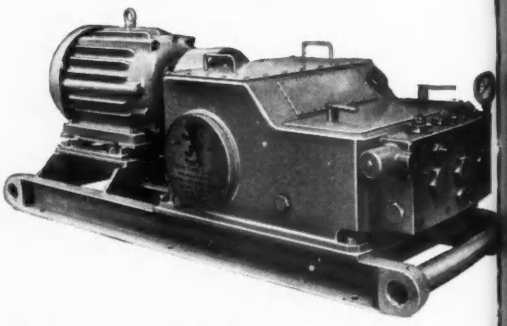

The unit is suitable for operation with water, water/soluble oil mixture and hydraulic oil.

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mittee Report, electro-precipitation of industrial mists and dusts, fluoridation, manufacturers' problems in disposing of effluents and trade wastes, problems of design in effluent-system plant, pumping, river pollution, sewage disposal without main drainage, treatment of radioactive waste materials, waste-water recovery, and water softening.

Full details of the exhibition and convention can be obtained from the organizers, Thunderbird Enterprises Ltd., 140 Cromwell Road, London, S.W.7.

British Scientific Exhibition in Moscow

Following a recent agreement between the Scientific Instrument Manufacturers' Association of Great Britain and the All Union Chamber of Commerce, Russia, 34 British scientific-instrument makers will show and demonstrate their latest equipment in Moscow at the Polytechnic Museum between June 18 and 29, 1960. This exhibition is entirely financed by the industry itself through the charges levied on the exhibitors and is, it is believed, the first British collective private-enterprise exhibition ever to be held in Moscow.

The Russians are very interested in many of the advanced types of instrumentation which exhibitors will be showing and have agreed to consider purchasing those which they may require. The exhibition will be attended by a large number of representatives from all the academic, medical, industrial, and scientific establishments, including laboratory and research institutions, in the Soviet Union, all of whom will receive invitations to attend.

The Exhibition contractors not only have to mount the exhibition, but will have to be responsbile for the packaging and shipping of the exhibits and the personal travel of the exhibitors' staff. Also, British electricians, sign-writers, carpenters, labourers, and executive control staff must also be sent, together with stands, furniture, and all accessories.

Mercury-Arc Rectifier/Inverter Equipment for a Steel Mill

Believed to be the first rectifier installation of its type ever to be used in a high-powered rolling mill in Great Britain, mercury-arc rectifier/inverter equipment supplying a 4000-hp reversing billet-mill drive has recently been commissioned by Associated Electrical Industries Ltd. at the Stockbridge works of Samuel Fox & Co. Ltd. The equipment is made up of pumpless steel-tank mercury-arc rectifier/inverters with a rating of 3200 kW r.m.s. and a voltage range from zero to 900 V, and is situated, with its associated grid-control equipment, on the gallery in the motor room. Anode reactors for each rectifier tank are mounted in frames above and integral with the rectifier cubicles, all the tanks being provided with full thermostatic temperature control.

D.C. circuit-breakers are mounted immediately below, on the floor of the motor room, together with a fast-acting armature reversal switch. A laminated-yoke exciter supplies the existing motor field. The control gear, housed in cubicles, comprises all necessary static amplifiers, transistorized sequence control systems, supervisory instrumentation, and alarm equipment. A closed-loop system of speed control is included in the equipment, with overriding limitation of current, voltage, and acceleration. On both a.c. and d.c. circuits, there is adequate protection in case of failure through overcurrent, back-fires, and other faults.

Three-Dimensional Industrial Television

Three-dimensional television for use in industry will be shown at the Instrument, Electronic, and Automation exhibition, to be held at Olympia, London, between May 23 and 28, 1960. Developed by Pye, of Cambridge, this new system—particularly useful for remote observation, control, and manipulation of materials and processes—can be attached to any existing closed-circuit television installation. This is the first time in Britain that a three-dimensional television picture has been made possible when using only one chain of closed-circuit television equipment.

A Pye master slave manipulator can be used in conjunction with the new equipment for remote handling, stereoscopic vision enabling an operator to pick up any article by remote control. The three-dimensional effect is obtained by a mirror beam-splitting system at the camera position and by an arrangement of mirrors at the monitor end.

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NEW TECHNICAL BOOKS

Electronic Computers—Principles and Applications. 2nd edition, 1960. By T. E. Ivall. 272 pp., 125 illustrations. Publishers: Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1. Price: 25/–.

Since the appearance of the first edition of this excellent book in 1956 and its second impression in 1957, so many developments in the field of electronic computers have been taking place that the publication of a revised edition was inevitable. As a result, this second edition has been almost entirely rewritten, most of the previous diagrams have been replaced by new ones, and illustrations of more modern electronic computing equipment have been introduced. In addition, three new chapters have been added, dealing respectively with analogue-computer circuits, the programming of digital computers, and the evolution of machines of the future.

In essence, the book is directed towards those who are starting to take an interest in electronic computers. As such, it is neither intended as a textbook nor as a work for computer experts, but as a means of giving a reasonably broad picture of electronic computing as a whole, in terms of a non-mathematical introduction to the principles and applications of computers employing valves, transistors, and other electronic devices. The author, who is joint-assistant editor of *Wireless World*, writes well and lucidly, and there can be no doubt that this book will be welcomed by the ever-increasing numbers of technicians, engineers, and students who are interesting themselves in this subject.

Exploding Wires. Edited by William G. Chace and Howard K. Moore. 373 pp., 205 illustrations. Publishers: Plenum Press, Inc., New York, and Chapman & Hall, Ltd., 37 Essex Street, London, W.C.2. Price: 76/– ($9.50).

Although experiments in connection with the electrical disintegration of wires were carried out nearly 200 years ago, true scientific interest in the subject is of recent origin. Thus, while the exploding-wire phenomenon has long interested experimenters, sometimes for the phenomenon itself and sometimes as a means to an end, scientific interest in the actual phenomenon dates from the 1920's, when Anderson showed that the temperatures produced by exploding wires approached those of the sun. Even now, however, the mechanism of wire explosions is only poorly understood, some parts of the process being without any explanation, while others have been explained by a number of theories.

To-day, exploding wires are used in various applications, one of the commonest being as a relatively simple method of taking photographs with microsecond exposures, by virtue of the single pulse of extremely short and intense light output produced by a wire explosion. Also, as wire explosions are accompanied by shock waves and since the time of occurrence of a wire explosion can be controlled within thousandths of a microsecond, they constitute a desirable method of producing small shock waves at a predetermined time.

There can be no doubt that this most interesting book—the first monograph on exploding wires ever to be published in any language—is of exceptional value to all workers in the fields of high-speed photography, shock waves, and thermonuclear research, as well as to scientists, technologists, and students concerned with fluid physics. Based on the Conference on the Exploding-Wire Phenomenon, conducted in April 1959 by the Geophysics Research Directorate of the U.S. Air Force Cambridge Research Centre, with the co-operation of the Lowell Technological Institute Research Foundation, the book not only records the Conference, but fills a large gap in the literature on this subject. In addition to a brief survey of exploding-wire research, it contains 25 papers from various experts in their field, i.e., 13 papers on the theoretical and experimental aspects of the exploding-wire phenomenon, 4 papers on shock waves, and 8 papers on applications and techniques, all of which give a clearer picture of what happens in a wire explosion and provide a greater understanding of the subject.

Zone Refining and Allied Techniques. By N. L. Parr, M.I.Mech.E., F.I.M. 200 pp., 143 illustrations. Publishers: George Newnes Limited, Tower House, Southampton Street, Strand, London, W.C.2. Price: 40/–.

With the urgent need for elements and compounds of extreme purity, particularly for the production of transistors, there has been a rapid development in the technique of zone refining during the past few years. Essentially, zone refining is a simple process, but the author has considered (quite rightly) that a fair amount of background information on associated chemical and physical phenomena should be included in a book of this type, which is basically a comprehensive review of the subject from its practical, rather than its theoretical, aspects.

The author, who is head of the Metallurgical Division of the Admiralty Materials Laboratory, at Holton Heath, Dorset, writes with authority, as, indeed, is only to be expected from one who has often used zone refining in the preparation of metals and materials in a high state of purity. What is more to the point is that he is able to impart his knowledge clearly and concisely. The result is an interesting and instructive exposition, enlivened by numerous judiciously selected diagrams and photographs, of the technique of zone refining, with practical information on recent advances in laboratory methods and equipment, ranging from inexpensive and easily constructed apparatus to specially built complex installations for high-precision production.

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4. Pin Fasteners. Particulars are contained in a 4-page leaflet of a range of pin fasteners suitable for replacing a rivet shaft, a key, a set screw, a headed pin, a hub on a gear, or a bolt and nut. Basically, the pin fastener is a slotted tubular steel pin with chamfered ends, which can be easily driven into holes, where it is locked firmly in place by a spring action, regardless of impact loading, stress reversals, or severe vibration. In addition, the pin fastener is readily replaceable and can be re-used in the same hole.

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Address .....

6. Dust-Control System. Developed to overcome the problem of acid smut emission from oil-fired boilers, a special dust-control system is presented in a 6-page leaflet. The equipment, which is equally suitable for use with coal-fired boilers, comprises an insufflator which injects into the boiler flue gases a controlled concentration of finely divided alkaline hygroscopic precipitate, the particles of which provide nuclei for the absorption of acid. The particles are then subjected to a high degree of turbulence to ensure intimate mixing of the powder and gases and a maximum agglomeration. Subsequently, the particles are extracted from the gas stream by the centrifugal action of the "turbo-cell" dust collector. An important advantage of this system is the neutralizing of the acidity of the gases and of the entrained particles, which results in inhibition of corrosion and in reduction of the dew-point temperature of the gases.

7. Gear-Measuring Instruments. The range of gear-measuring instruments described in two 2-page leaflets includes rolling gear, involute, lead, and worm and wheel testers. For the involute testers, which are supplied to fit existing rolling gear testers or as complete units, a microscope eyepiece is provided to bring the stylus point into contact with the tooth flank, the stylus operating an electronic pick-up which, in turn, actuates a high-magnification recorder to show errors as deviations from a straight line.

8. Link V-Belts. The salient features of a range of special link V-belts are presented in a 10-page brochure. The construction of the belts allows free air circulation to dissipate the heat generated by internal friction during flexing, and, as each link belt takes equal share of the load, uneven wear is avoided. Being detachable, the belts eliminate dismantling costs where pulleys are mounted between bearings or in confined positions. It is also claimed that they contribute to quicker starting, reduce breakdown stoppages, and have a considerably longer service life than conventional belting.

9. Cylindrical Grinding Machine. Satisfying the demand for a precision-built grinding machine for large runs, as well as for small lots and single workpieces, a range of universal cylindrical grinding machines is dealt with in a 14-page brochure. The combination of symmetrical headstock and swivelling spindle gives the machine a wide working range and numerous setting-up possibilities and, thus, it may be used for work for which previously special machines were required. Furthermore, with the aid of special attachments, the field of application may be extended to cover convex, concave, profile, and polish grinding.

10. Welding Service. A profusely illustrated 60-page catalogue describes the various stages of a comprehensive welding and fabrication service provided by a leading firm from planning the operations to the actual welding and finishing of the work. Various welding processes employed in the production of pressure vessels and other heavy-plate work are described, and plating processes for steel tanks and other assemblies are also featured.

11. Air-Control Valves. The range of air-control valves described in an illustrated 4-page brochure includes cam-operated, pilot pressure-operated, direct pressure-release valves, as well as direct-operated double-solenoid valves for use in dusty conditions or where heavy duties have to be encountered. The valves are manufactured for a working pressure of up to 150 psi, and are adaptable for various methods of fixing, including flange, trunnion, and direct mounting.

12. Weatherproof Plugs and Sockets. Details are given in an illustrated 40-page catalogue of a range of weatherproof electrical accessories, such as plain plugs with earthed interior, plain and flanged sockets, and multi-pole plugs and sockets. Full specifications of the plugs and sockets, as well as wiring instructions, are also included.

so very small . . .

and so very trustworthy. This electro-magnetic counter is specially designed to be tucked away in coin-operated vending and amusement machines, and for other light duty jobs. It's tamper-proof because the cover is clinched through the bottom of the frame and the window is unbreakable. Designed with a minimum of moving parts which are made from highly wear-resistant materials. Counter is non-resettable, records up to 99,999 and returns to zero. Leaflet 3/5960 gives full details: do please write for it.

Standard specification

Operating voltage	200/250 volts A.C. 50 cycles. Also available 110/115 volts A.C. 60 cycles and a number of D.C. supplies.
Power consumption	4 watts.
Operating speed	300 counts per minute (recommended maximum).
Figures	5. Non-resettable. White. $\frac{1}{8}$" high on black wheels.
Case	Plated case. Base mounting. 12" trailing leads.

type 1200 light duty electro-magnetic counter

COUNTING INSTRUMENTS LIMITED

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wb

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In the well-equipped works of Herbert Morris Ltd. Loughborough, this CUNLIFFE & CROOM horizontal shows to advantage on the milling of wheel shafts.

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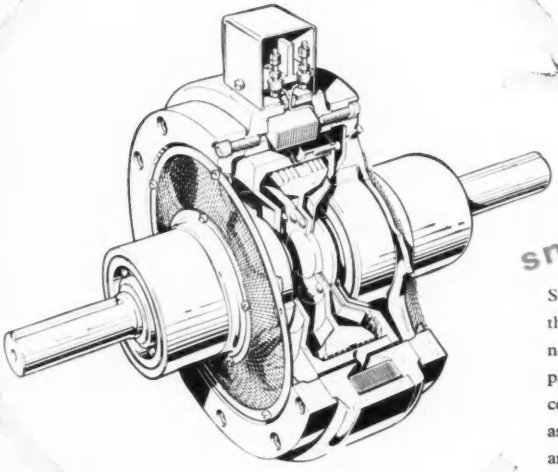
Magnetic Particle COUPLING



smooth yet positive

Smooth as a hydraulic coupling, but without the drag, positive as a friction clutch but never needing adjustment for wear, SMITHS magnetic particle COUPLING provides accurate control of torque without complications. It acts as a coupling or brake in either direction and can be remotely controlled from any distance.

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AP92

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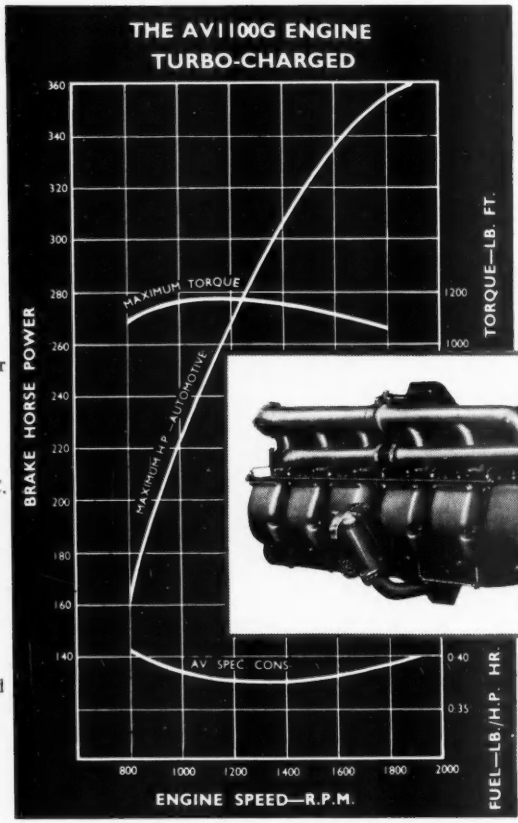

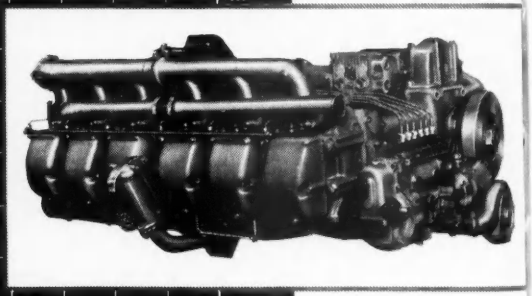

The AH/1100G horizontal Industrial Diesel

When you need power, whether for intermittent or long continuous running, power which is always instantly available, power at low cost, then the answer must be A.E.C. For mobile or stationary use, A.E.C. offer a range of high-torque industrial engines ranging from 50 b.h.p. to 275 b.h.p. Turbo-charged — a standard alternative — they go up to 360 b.h.p. Every A.E.C. diesel has behind it the experience of nearly 30 years in diesel design and production, and a world-wide service and spares organisation that never sleeps.

A.E.C. LIMITED · DIESEL ENGINE DIVISION
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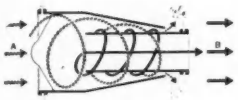
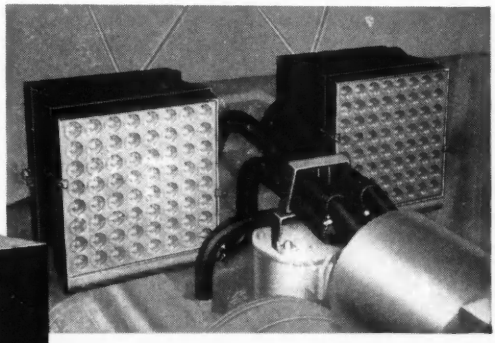
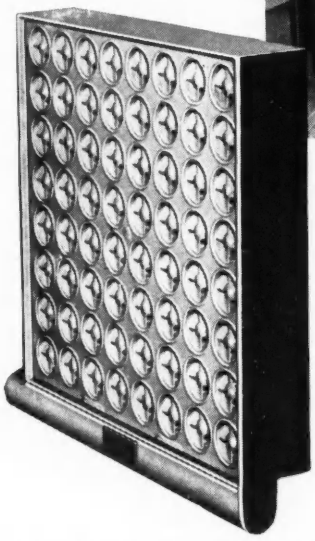


Rotonamic

air filters for DIESELS

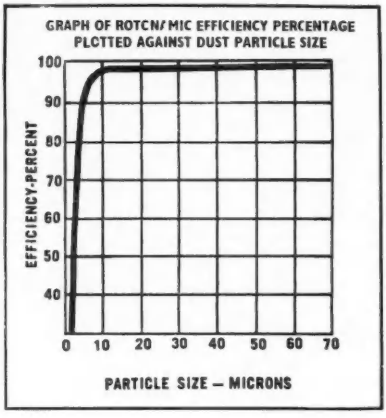
Static helical blades in the ROTONAMIC air filter give a whirling motion to the air as it enters at A. Still keeping to a helical path, the air is then induced to reverse direction, centrifuging the solids out of suspension before 90% of it is fed to the engine B. The other 10% is aspirated away with the removed solids through the tube at the base of the panel.





HIGH EFFICIENCY FILTRATION for DIESELS

Diesel life and efficiency goes up—when ROTONAMIC takes the abrasives out of the aspirated air. Road and railway transport system operators report: "periods between overhauls extended by hundreds of working hours. Greatly extended engine life"



NO MAINTENANCE and extremely high efficiency are the most important money-saving factors of ROTONAMIC air filters for diesels. Aspiration of dust particles can be provided by a simple extractor operated from the engine exhaust system. ROTONAMIC filters are made in England by INTERMIT LTD. Please write for leaflet FRC9.

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- Cut width compensation on tracer head.
- Fitted with Hancock roller drive — no physical contact between tracer and drawing.

The Hancoline is available in four cutting widths. The largest size can profile plates up to 10 feet wide in one setting. A Duplex port and starboard machine equipped with Hancoline tracing is also available.

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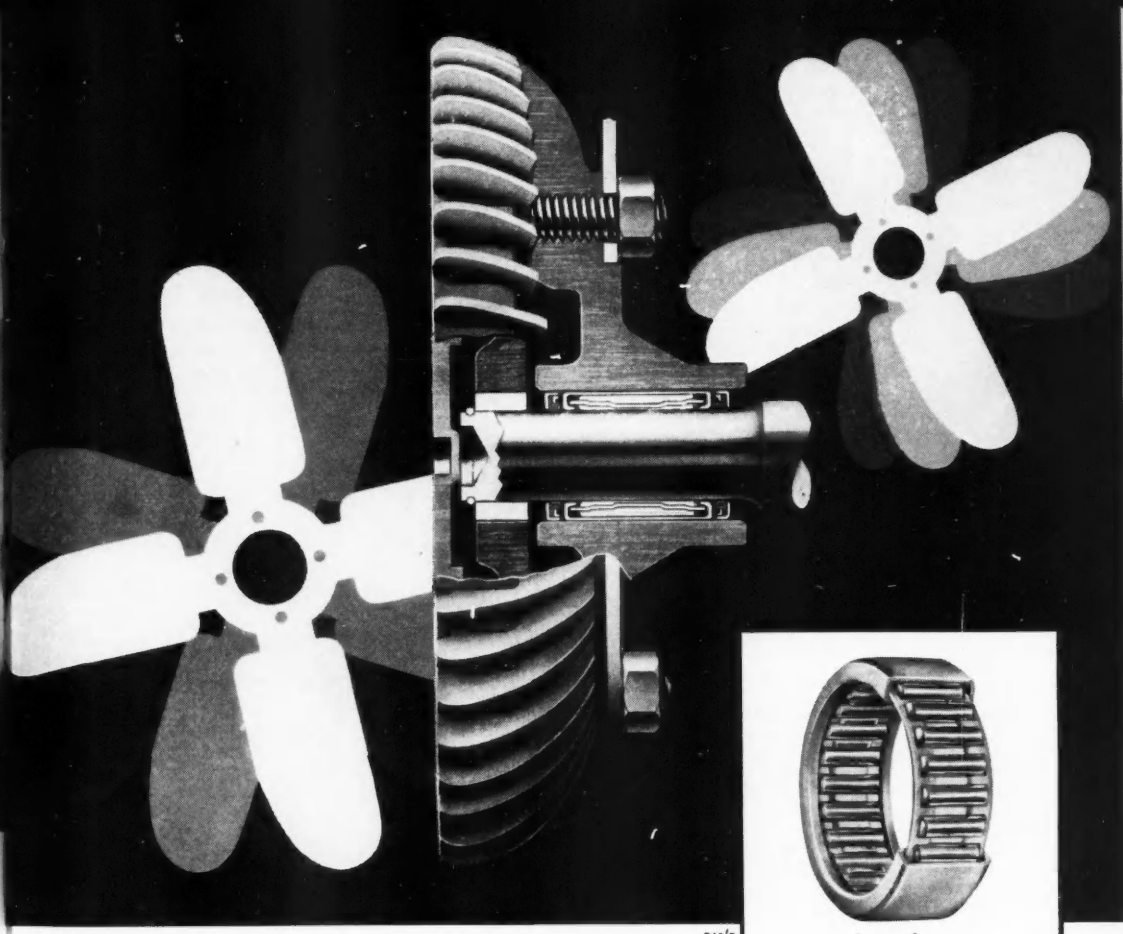


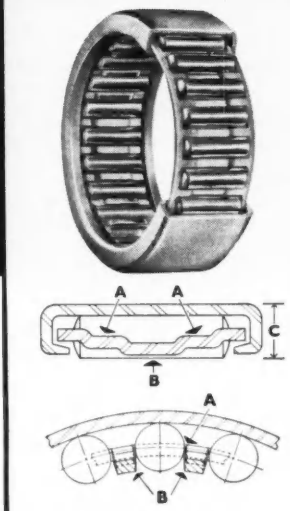
B60/B

If you want a bearing with economy, stability and lasting lubrication—

Torrington can provide it. The design of the automobile engine fan illustrated above called for two ball bearings to reduce fan horsepower and noise. By replacing them with one Torrington Drawn Cup Roller Bearing the customer has simplified the design and reduced costs.

This bearing firmly supports the drive housing and fan, so that they run true despite possible couple loads due to gyroscopic action. Ample lubricant reserve capacity permits pre-lubrication for the life of the fan drive.

Many new opportunities for economy, design simplification and operating improvements are opened up to engineers and designers by the new Torrington Drawn Cup Roller Bearing. The services of our Bearings Division are offered to help you with your development work.



- *rollers end-guided at pitch line (A)*
- *shaft-riding retainer (B) designed to permit lubricant circulation*
- *high capacity in small cross section (C)*
- *efficient at high speeds*
- *low unit cost*

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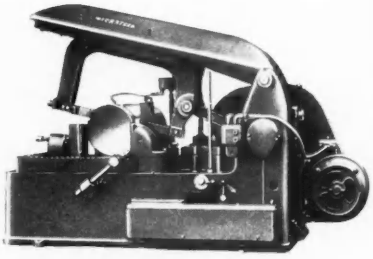
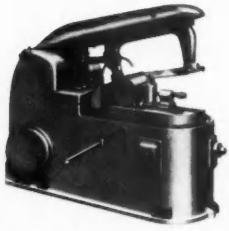
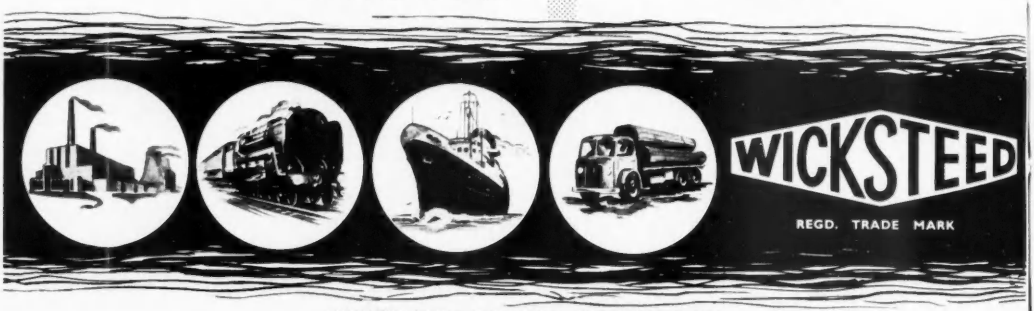


No. 12
12" × 12" Capacity



No. 8
8" × 8" Capacity
Hydramatic Machine



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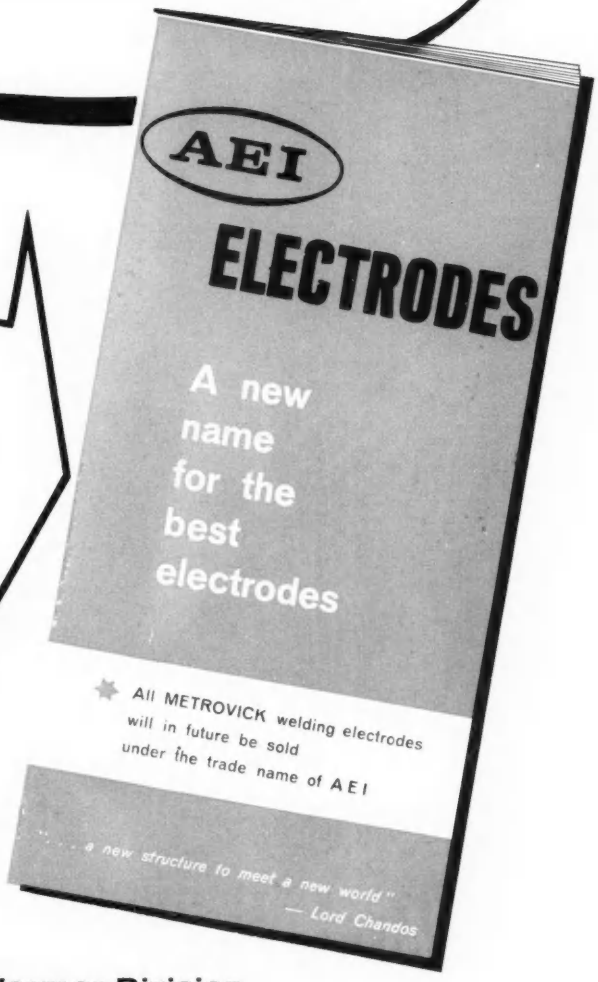
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L12

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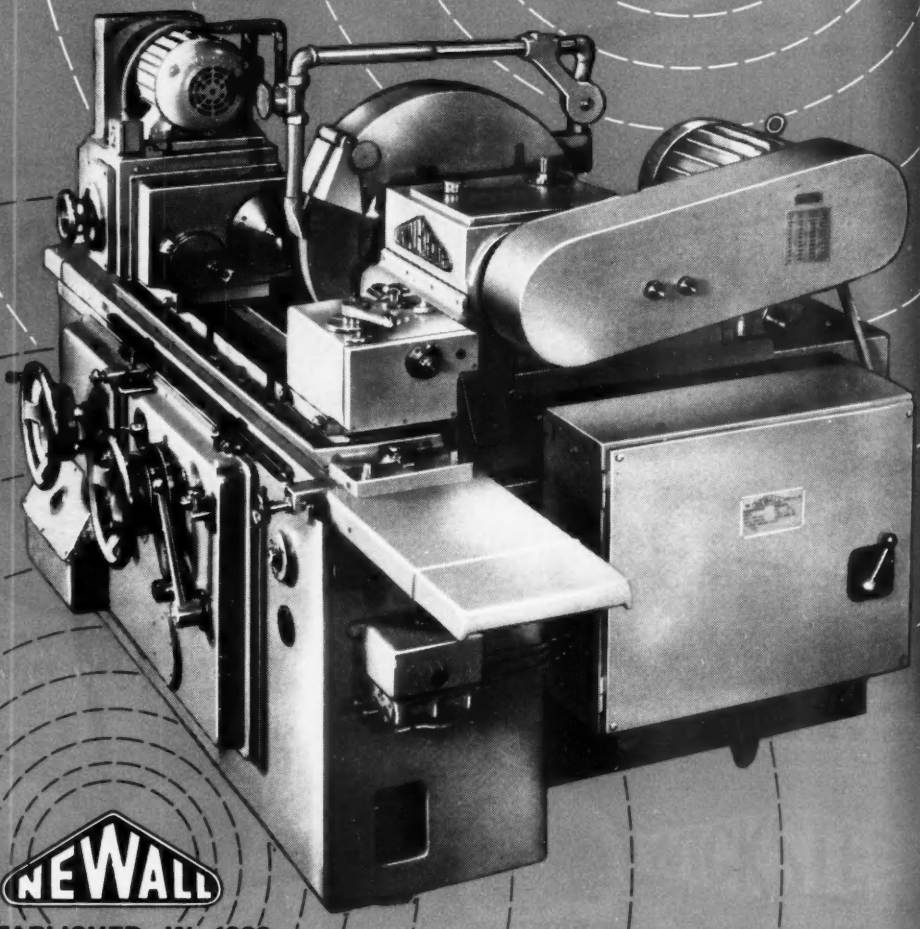

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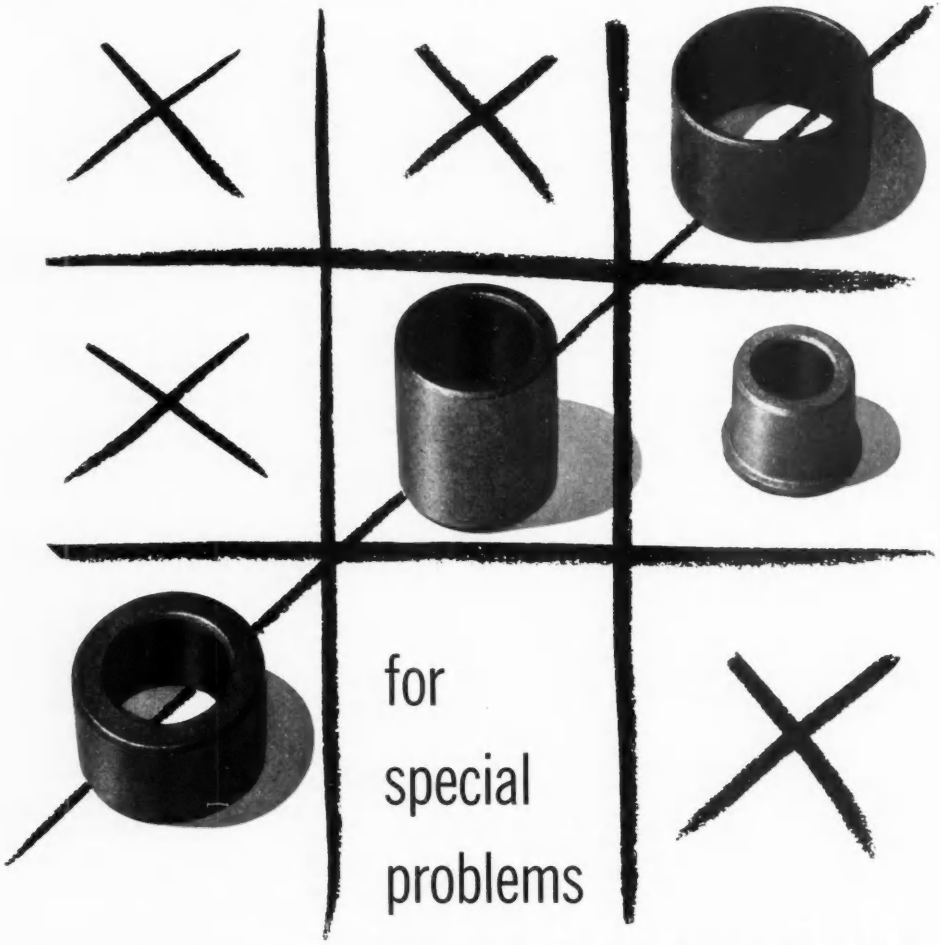

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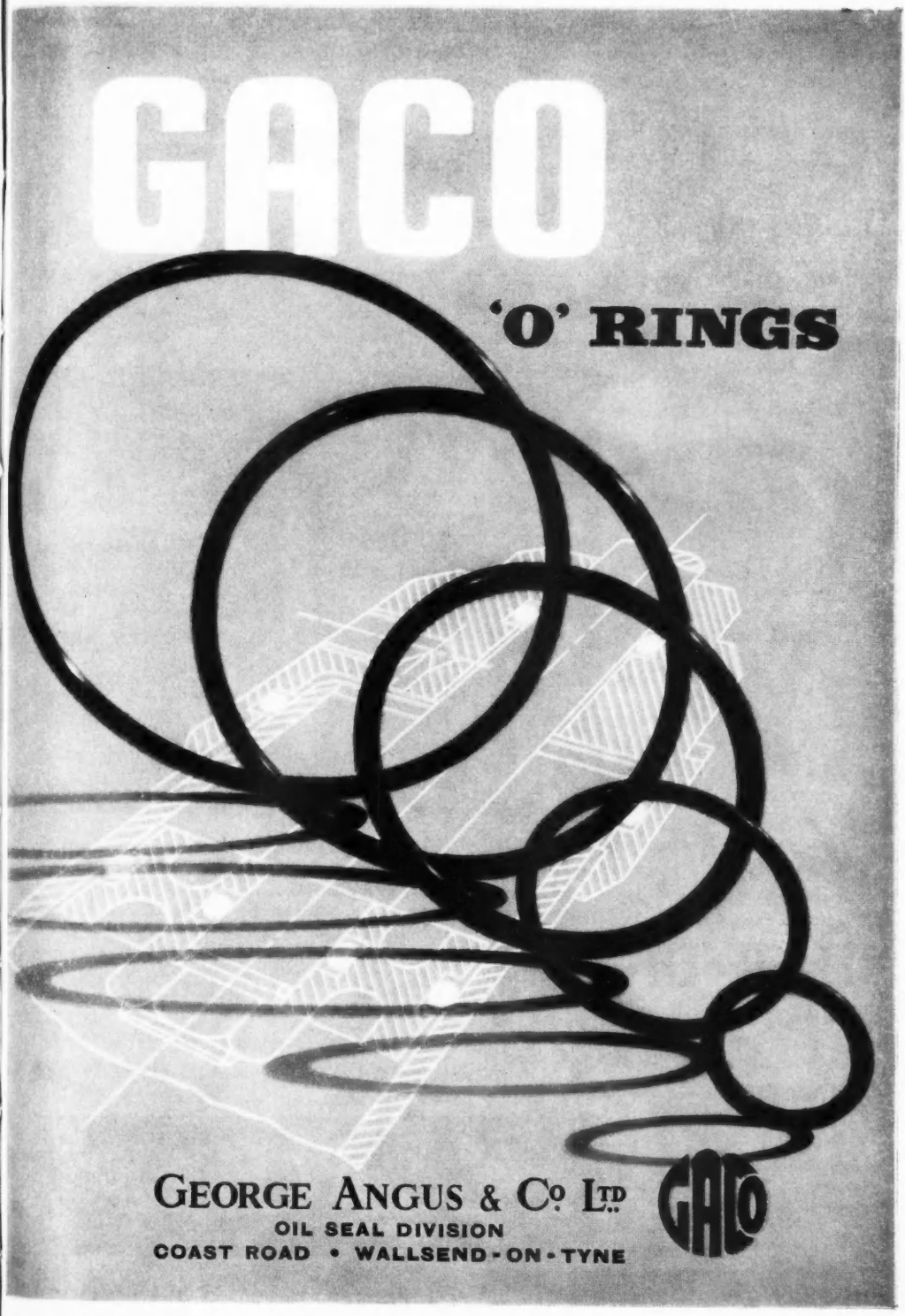
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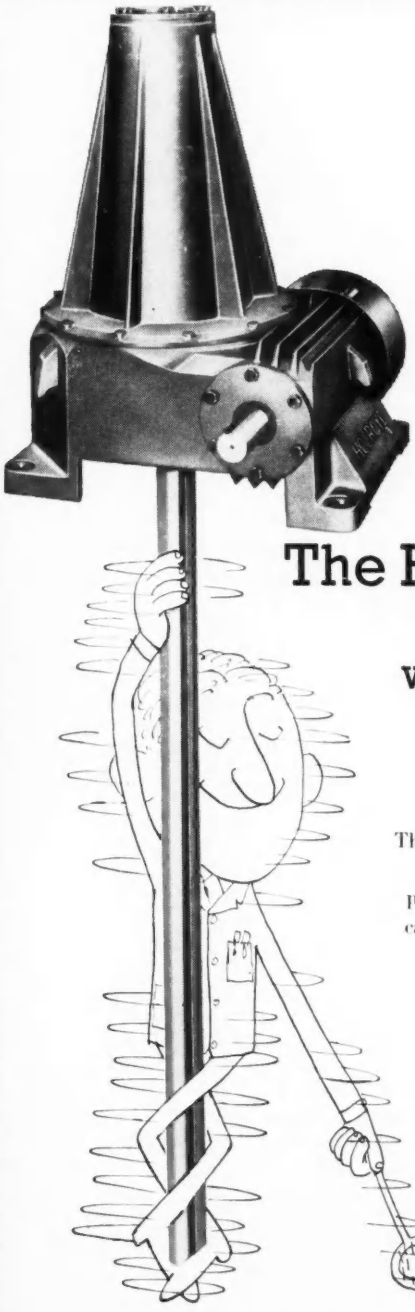
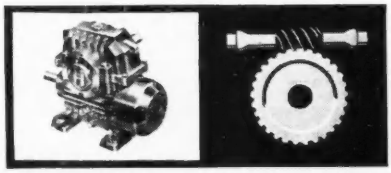


The Holroyd 'Top Hat'
holds the shaft steady while you stir things up

Its full name is Agitator-type-Worm-Speed-Reducer-With-Extended-Top-Bearing and it is particularly useful in the chemical and allied industries for mixer and stirrer drives. The extension of the top bearing within the gear box gives the shaft extra rigidity for the mounting of propellers, mixing blades, or fans. The output shaft can be of any length and project either up or down. There is a special sealing arrangement on the underside of the box which prevents oil leakage when the shaft projects downwards.

Holroyd



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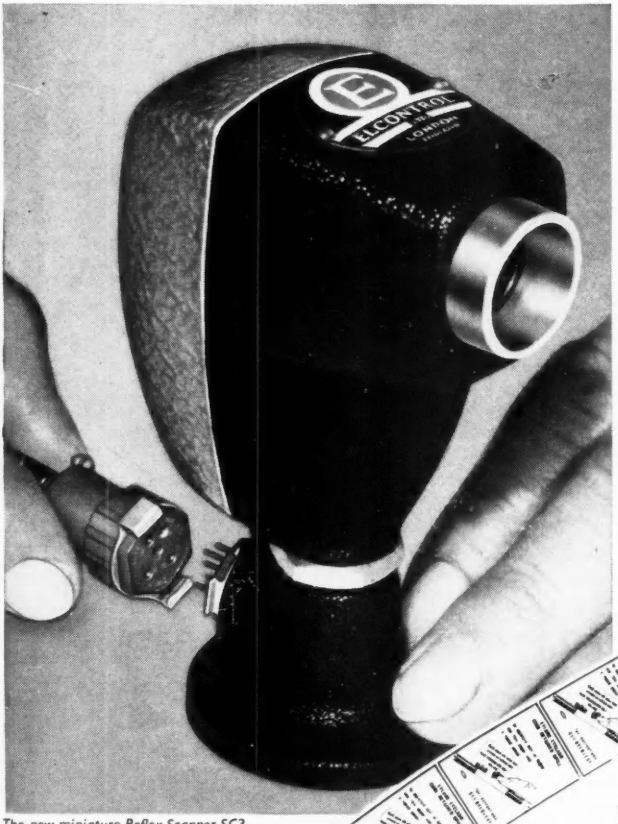
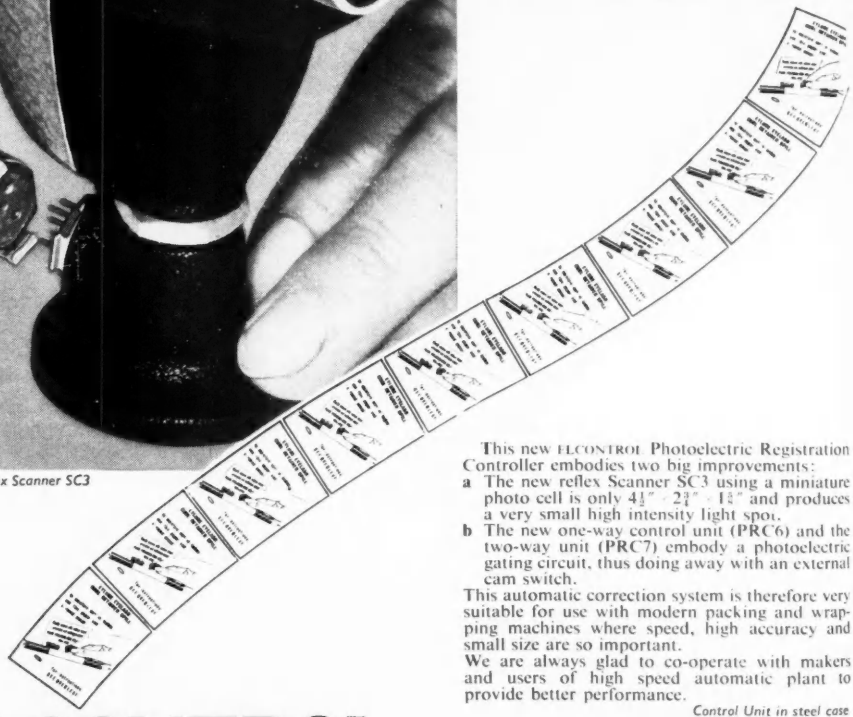


The new miniature Reflex Scanner SC3

positive control

for label cutting, wrapping and folding machines



This new ELCONTROL Photoelectric Registration Controller embodies two big improvements:

a The new reflex Scanner SC3 using a miniature photo cell is only $4\frac{1}{2}$" × $2\frac{3}{4}$" × $1\frac{3}{8}$" and produces a very small high intensity light spot.

b The new one-way control unit (PRC6) and the two-way unit (PRC7) embody a photoelectric gating circuit, thus doing away with an external cam switch.

This automatic correction system is therefore very suitable for use with modern packing and wrapping machines where speed, high accuracy and small size are so important.

We are always glad to co-operate with makers and users of high speed automatic plant to provide better performance.

Control Unit in steel case

ELCONTROL

Regd. Trade Mark

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PRC1

here is a man holding the answer
to his racking problems

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Cut it to the shape you want—
it holds together because it is welded together

Weldmesh is a registered trade mark and is supplied direct to users by the sole manufacturers:

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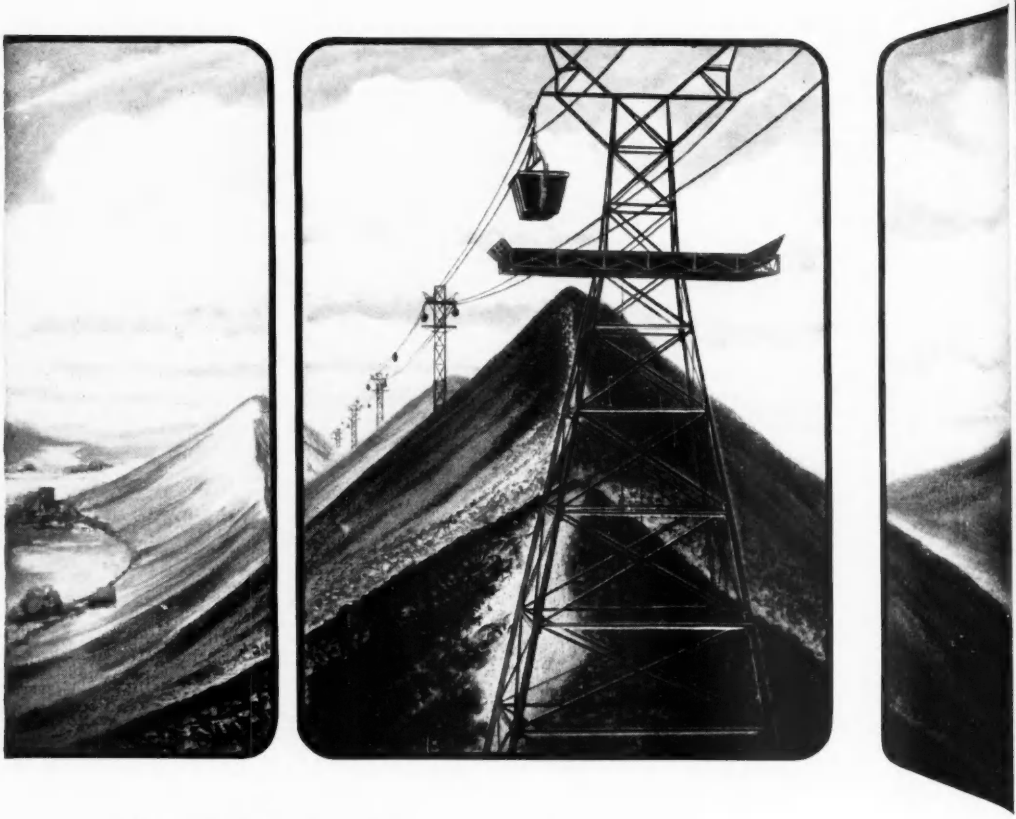

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. . . wise engineers use ROCOL Molytone greases to ensure against breakdown and to increase the period between essential maintenance operations on difficult perhaps dangerous to get at installations.

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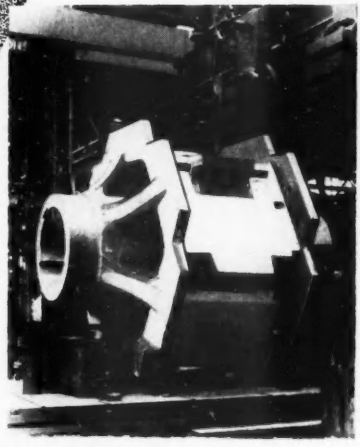

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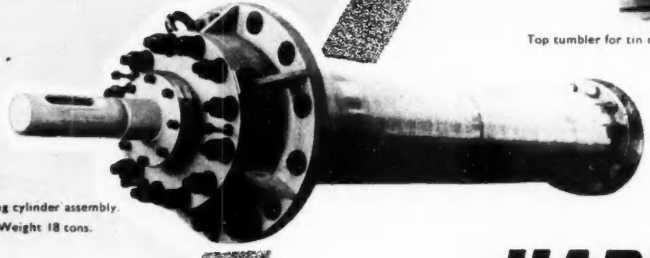

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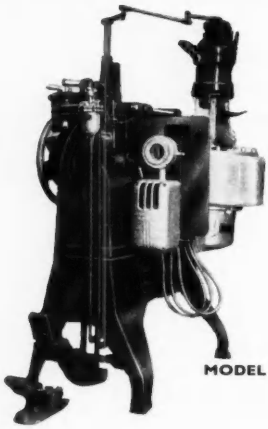

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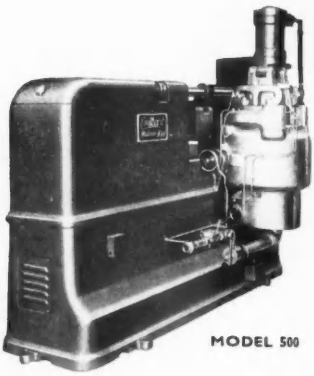

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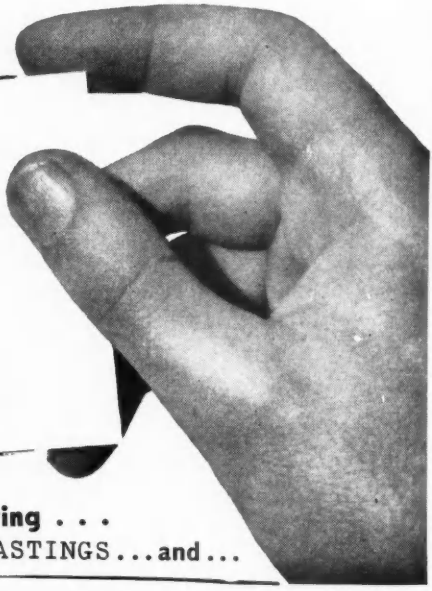

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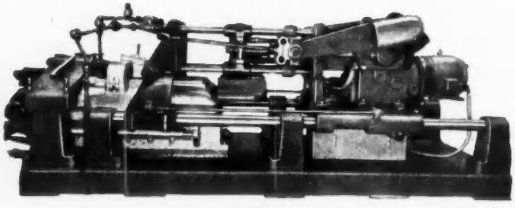

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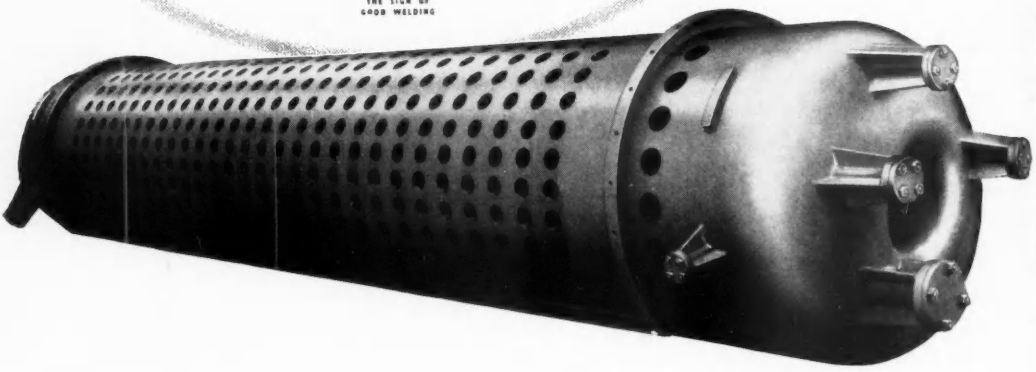

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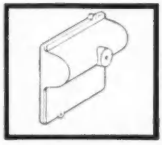

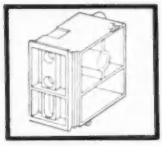

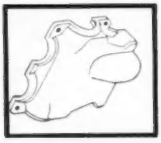

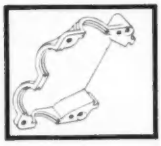

60 amp. Input Junction Box moulded by A.E.I. Plastics (Aldridge) Ltd. for Siemens Edison Swan. The four moulded components are shown in the inset drawings.

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Fig. 1609

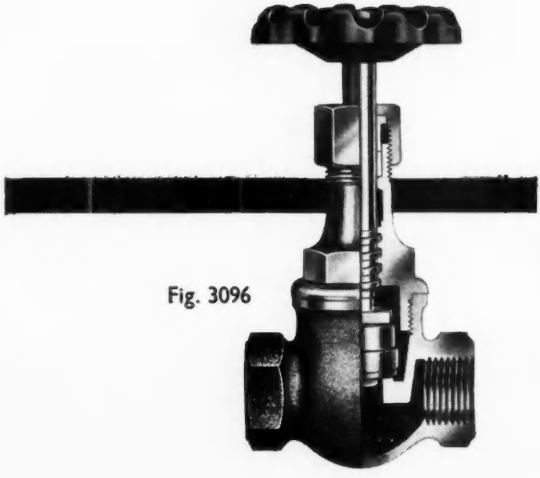

Fig. 3096

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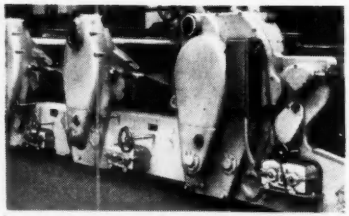

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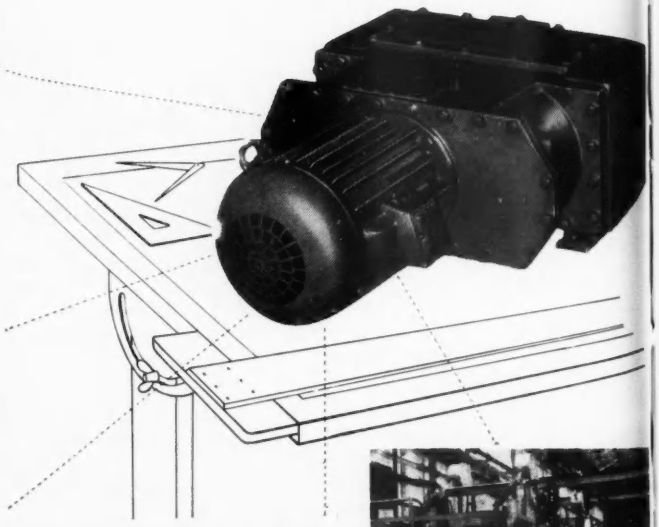
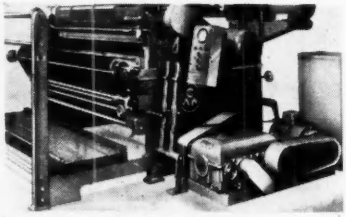
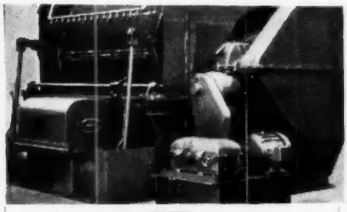




DOUBLE CARPET SHEARING MACHINE
Courtesy William Whitely & Sons Ltd.



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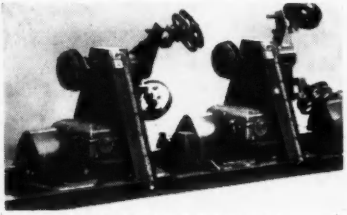

RUBBER TAPE LAPPING MACHINE
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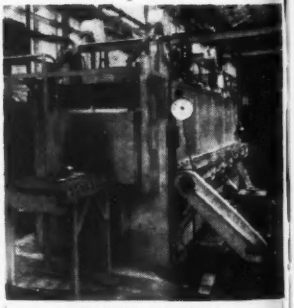

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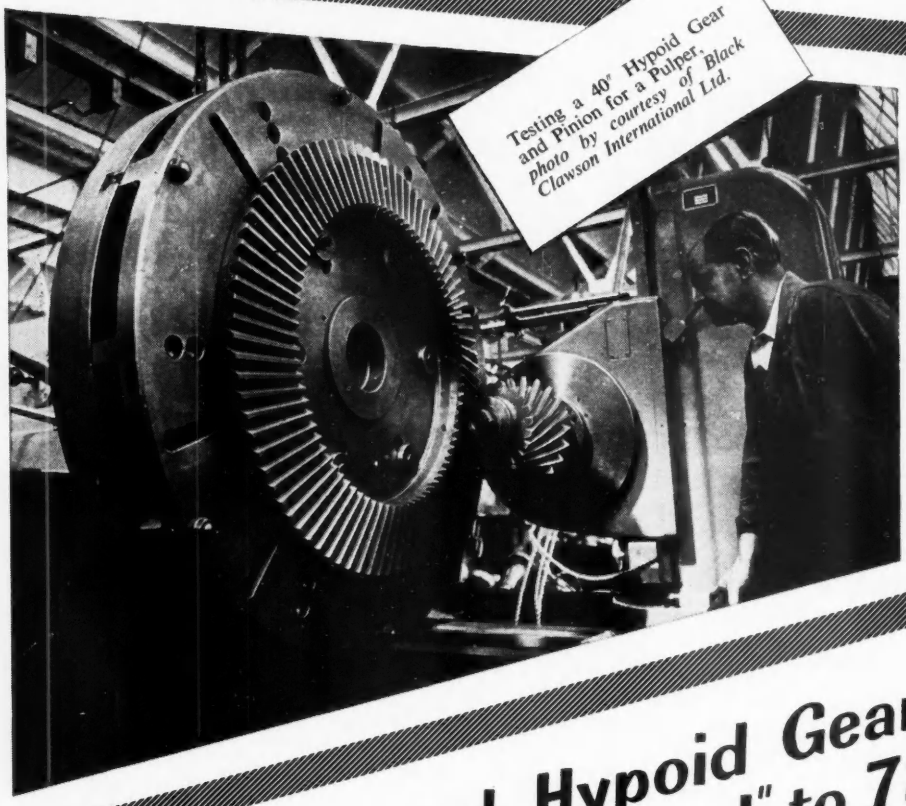

Testing a 40" Hypoid Gear and Pinion for a Pulper. photo by courtesy of Black Clawson International Ltd.

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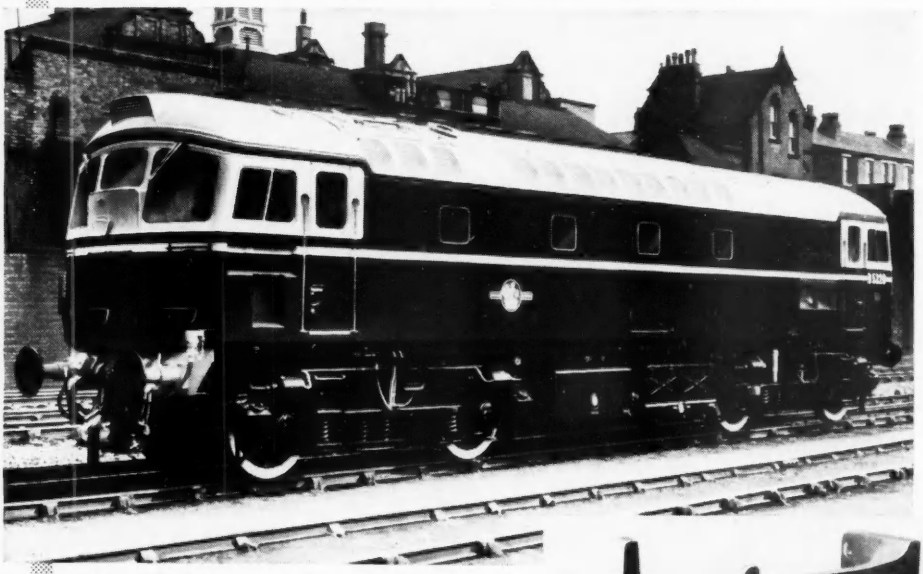
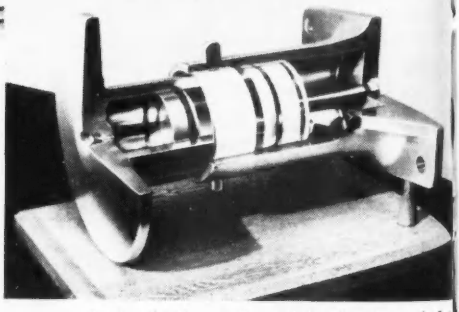


Type 2 Diesel Electric Locomotive built by The Birmingham Railway Carriage & Wagon Co. Ltd. for the British Transport Commission (Scottish Region, British Railways), on which are buffers made by Oleo Pneumatics Ltd., Kenilworth, including 'Maranyl' nylon bearings.



Section of railway buffer made by Oleo Pneumatics Ltd., Kenilworth, showing bearings made from 'Maranyl' A100

Bearings made from 'Maranyl' A 100 nylon allow railway buffers to work freely

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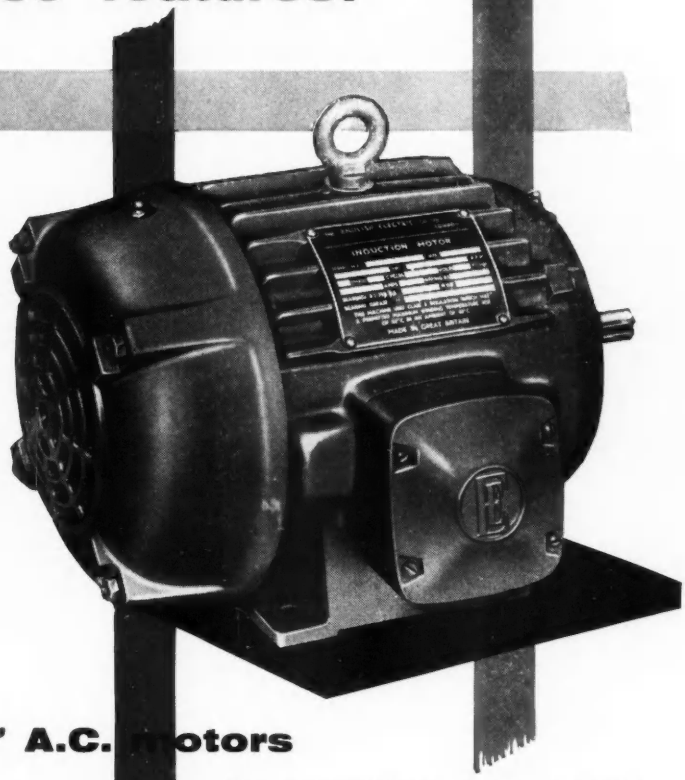

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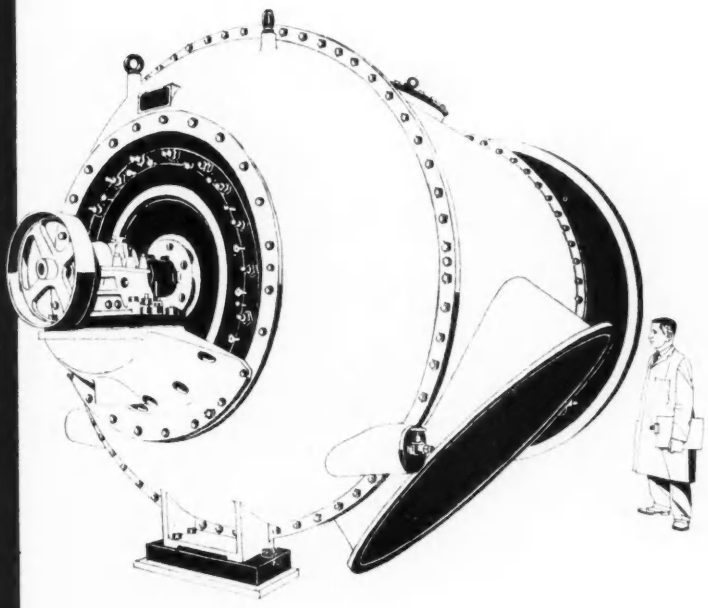

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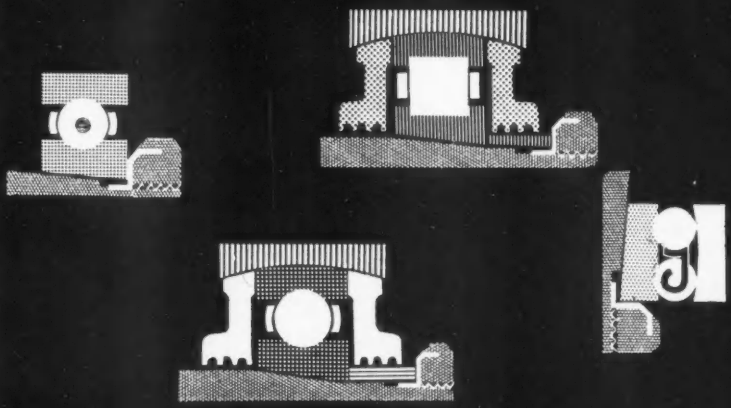

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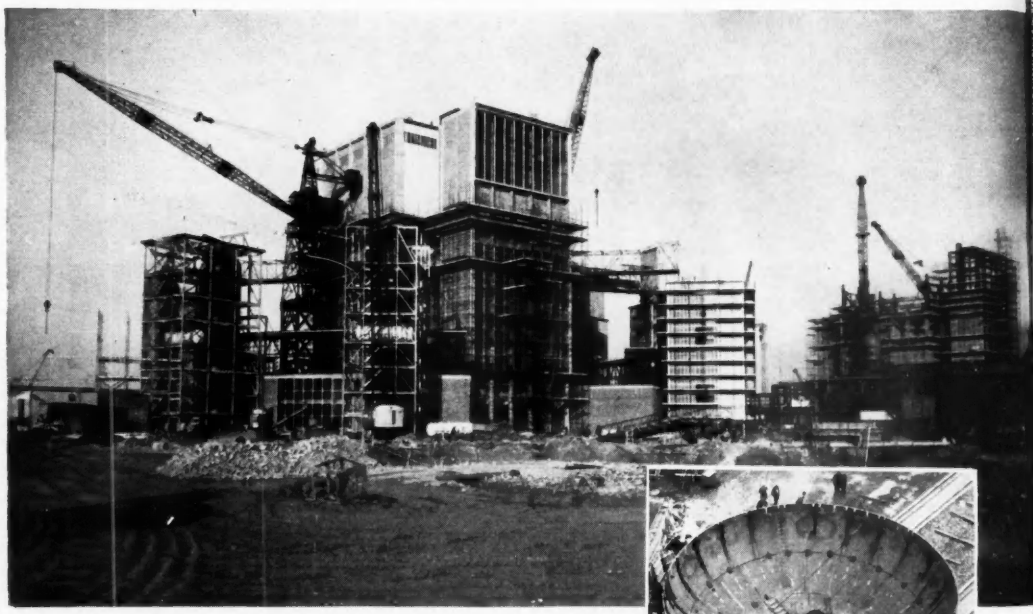

Pyrogas—one of the Saturn industrial gases—and Saturn welding equipment are extensively employed in the construction of this mighty Berkeley Nuclear Power Station project. Saturn designed the pre-heating burners (with the assistance of the manufacturers, John Thompson Ltd.) . . . and supplied the burner parts for the Pyrogas/Air mixture prior to the rake burners, the hoses, regulators and the individual Torches.

Saturn also manufactured the 60 cylinder and 40 cylinder manifolds. Saturn is doing an important job at Berkeley—and on many other big industrial projects. Can we help you?

These photographs were taken at Berkeley Nuclear Power Station, which is being built for the Central Electricity Generating Board of Great Britain by A.E.I.—John Thompson Nuclear Energy Co. Ltd. In the smaller picture, the lower bowl of No. 1 Reactor vessel is being assembled in a temporary shelter, prior to being lifted into permanent foundations.

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BRANCHES: GLASGOW · ALDRIDGE · MANCHESTER · SHEFFIELD
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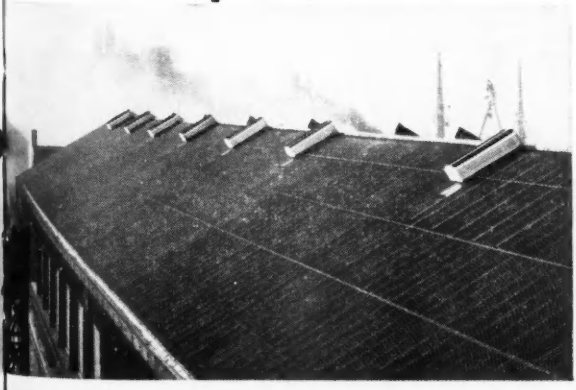
Place: ARTHUR GUINNESS SON & CO
Pomona Docks, Manchester Region.



Exhaust gases from fork lift trucks and lorries were once a major problem in this storage shed. Colt experts were called in to make a scientific analysis and on their recommendation a series of Colt S.R.C./3080 High Duty Extract Ventilators was installed. Fumes no longer bother anyone.

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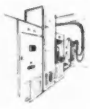 **FIRST**

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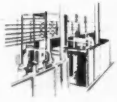
FIRST 

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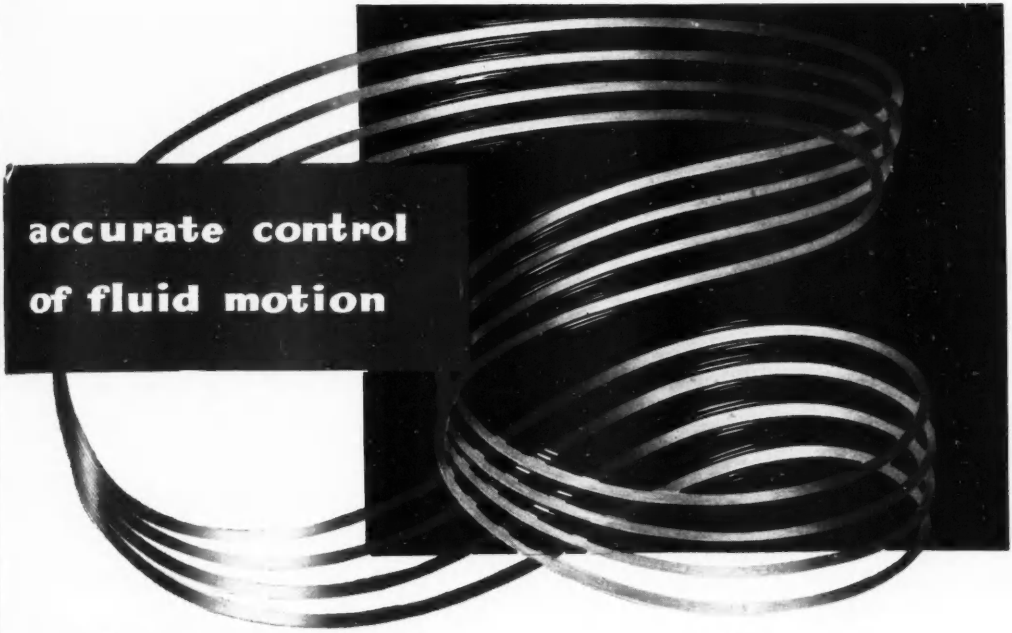

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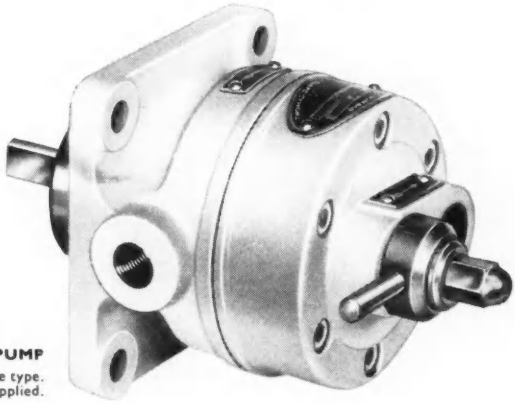

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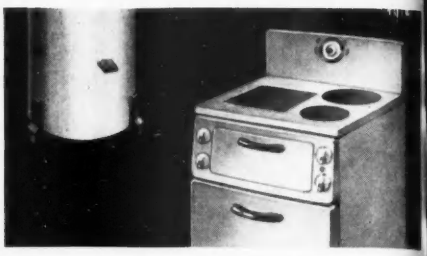
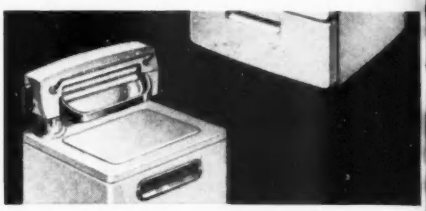


Perfect colour retention



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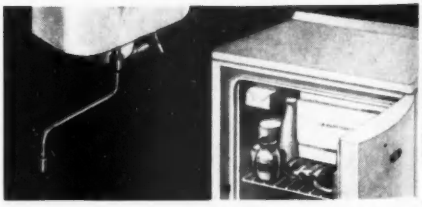
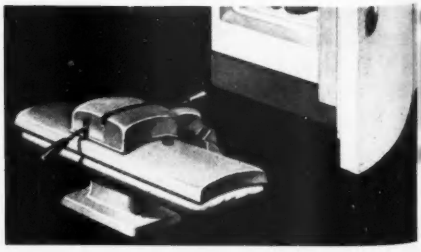


Increased durability



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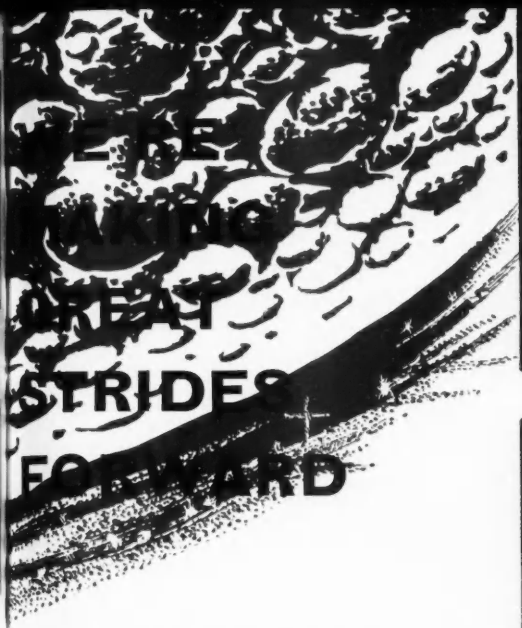

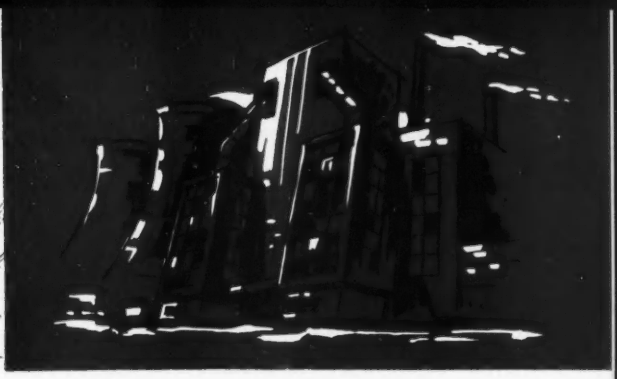

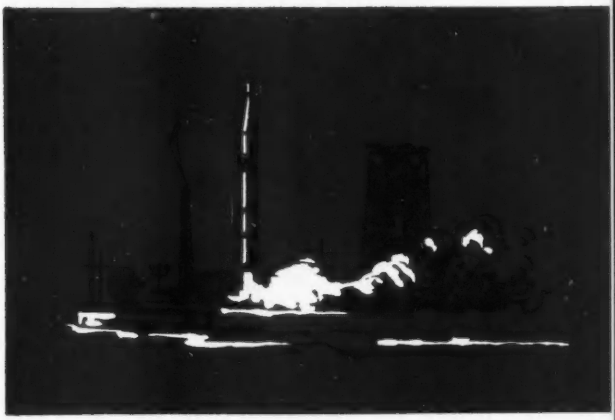

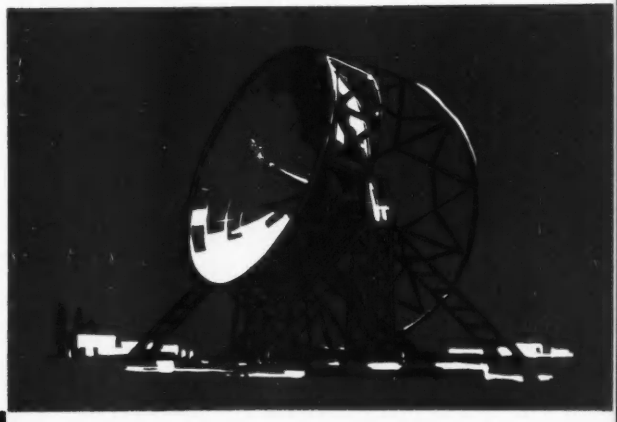

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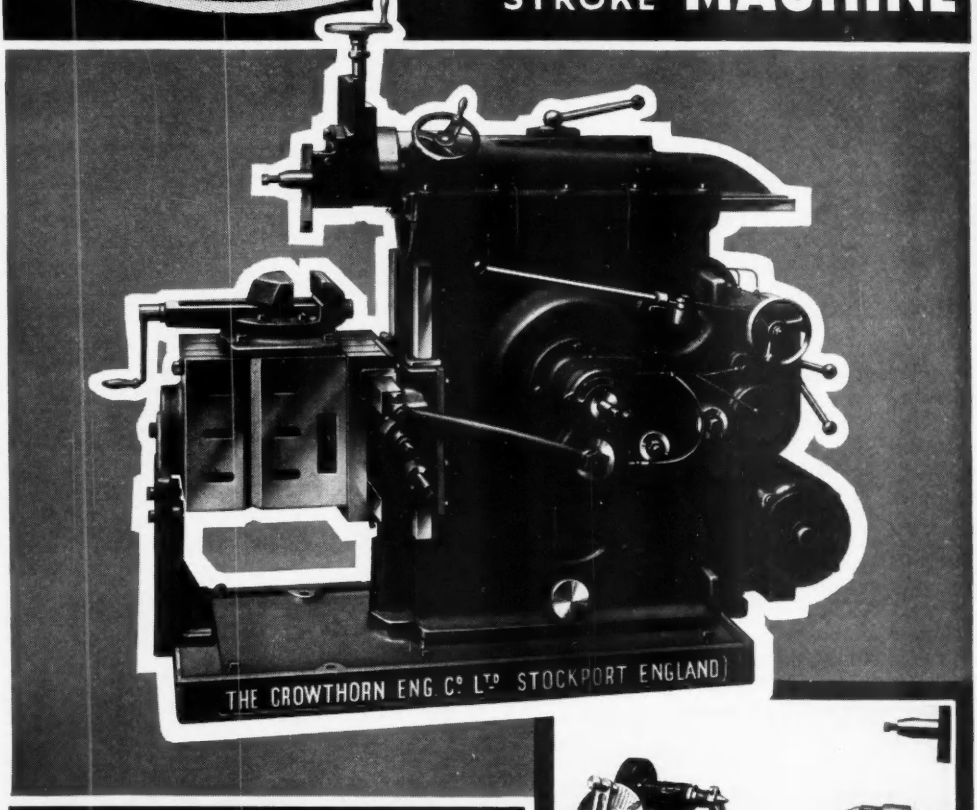

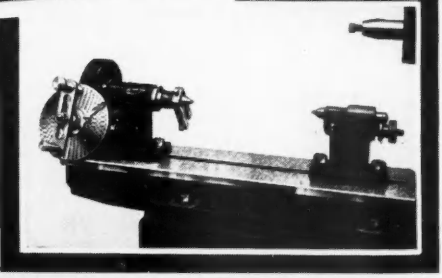

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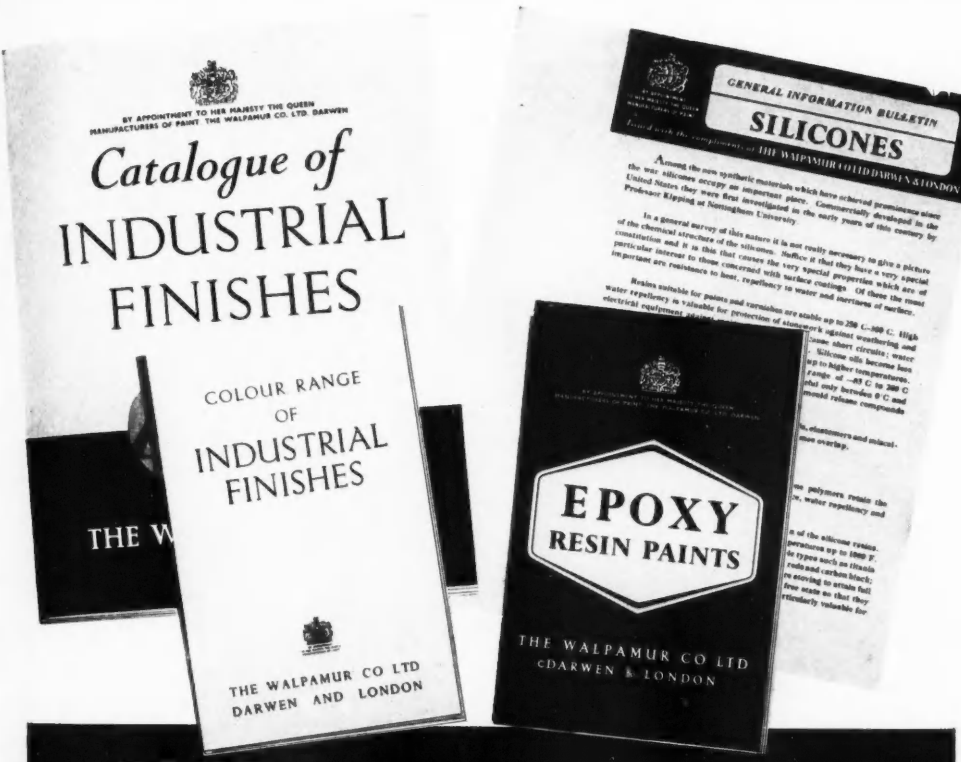

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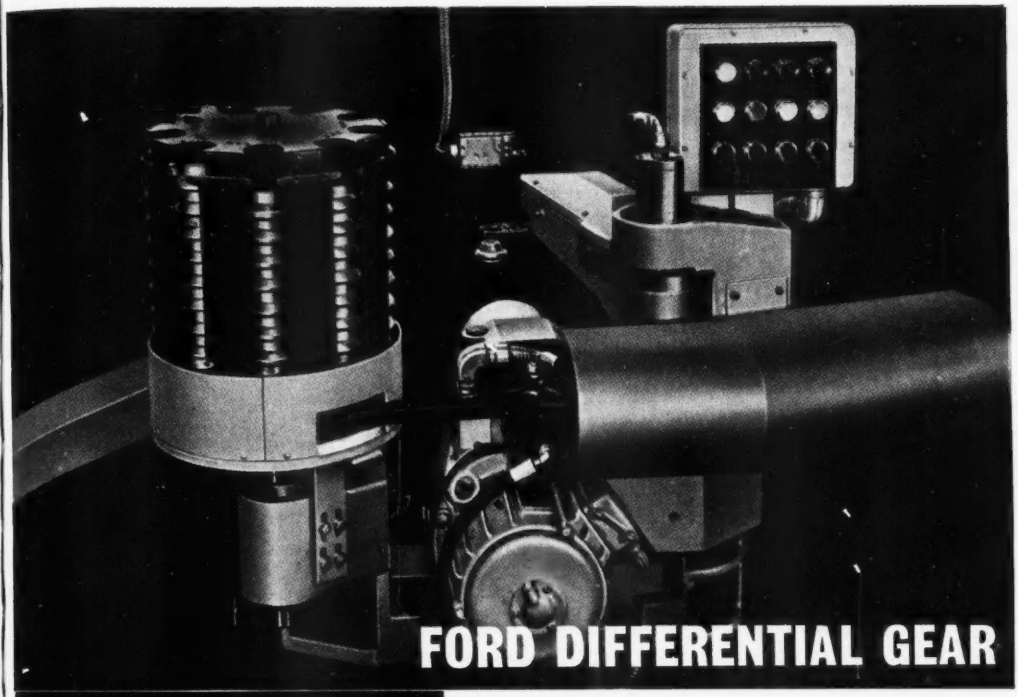

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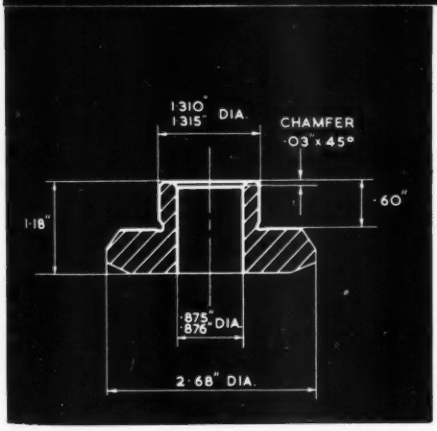

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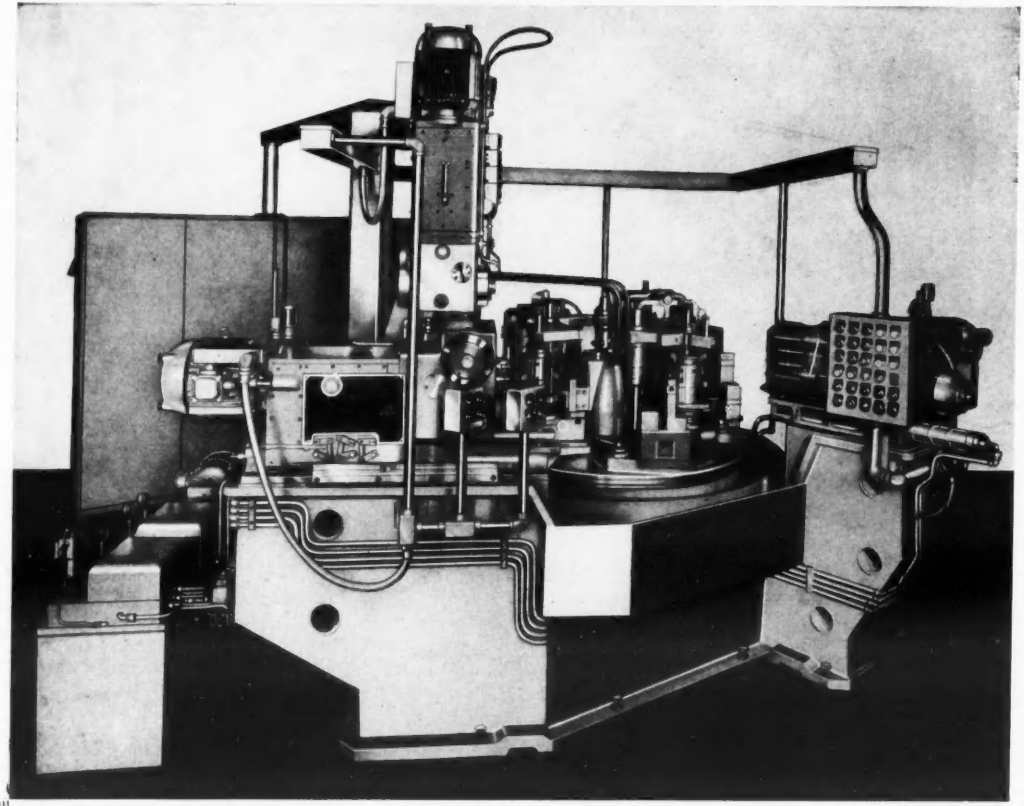

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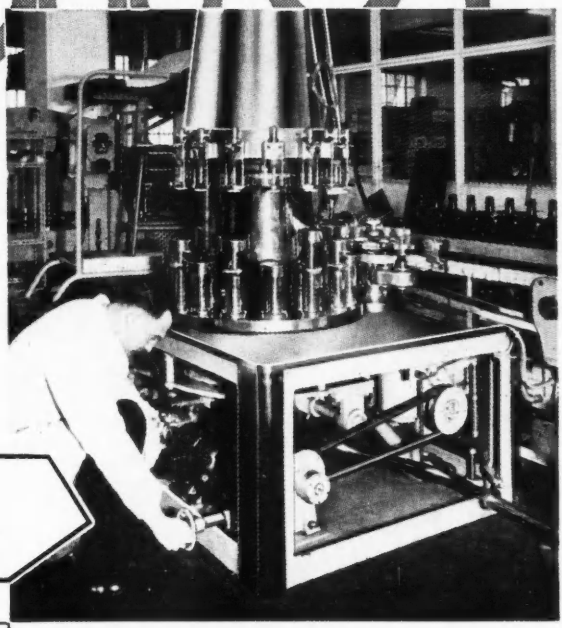

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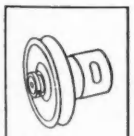

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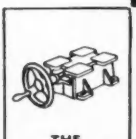

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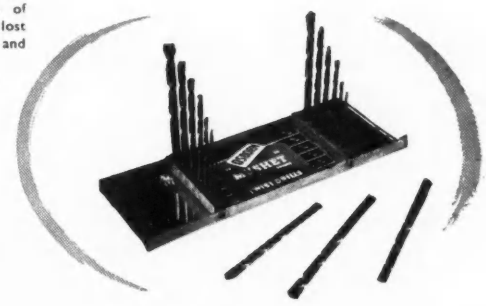

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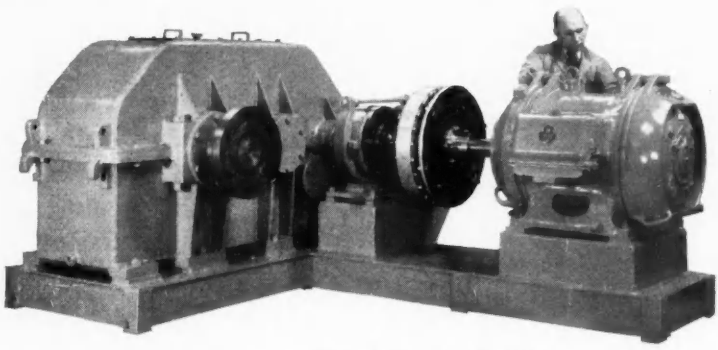

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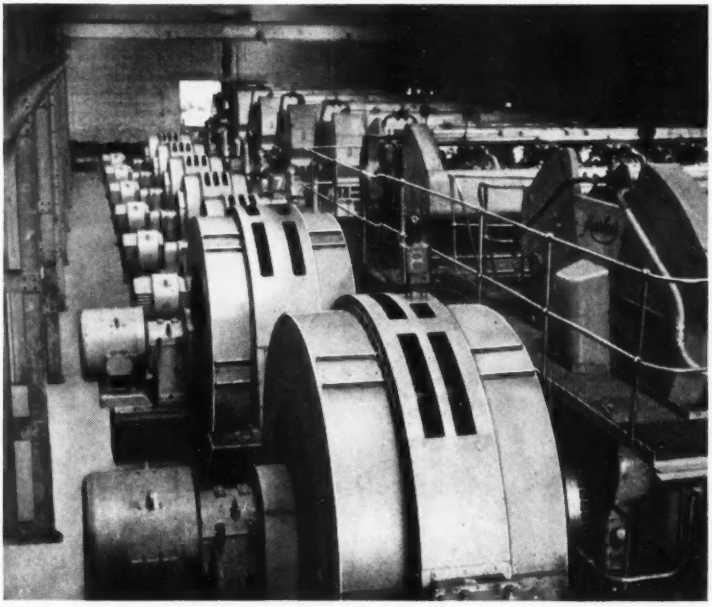
with the exception of Douglas.



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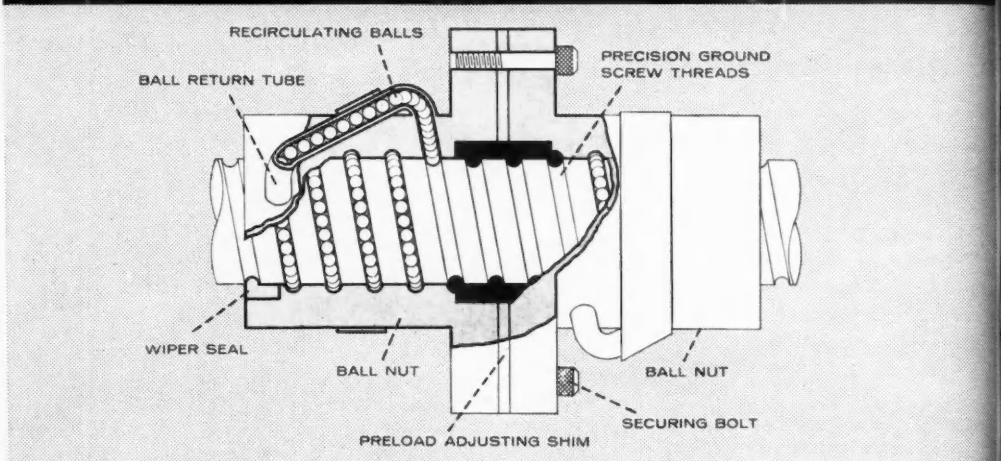

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For further information please write to:
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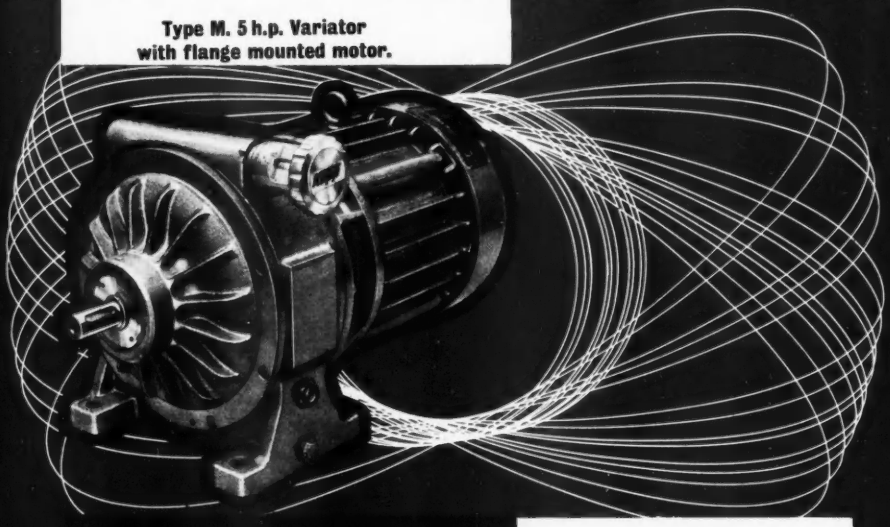

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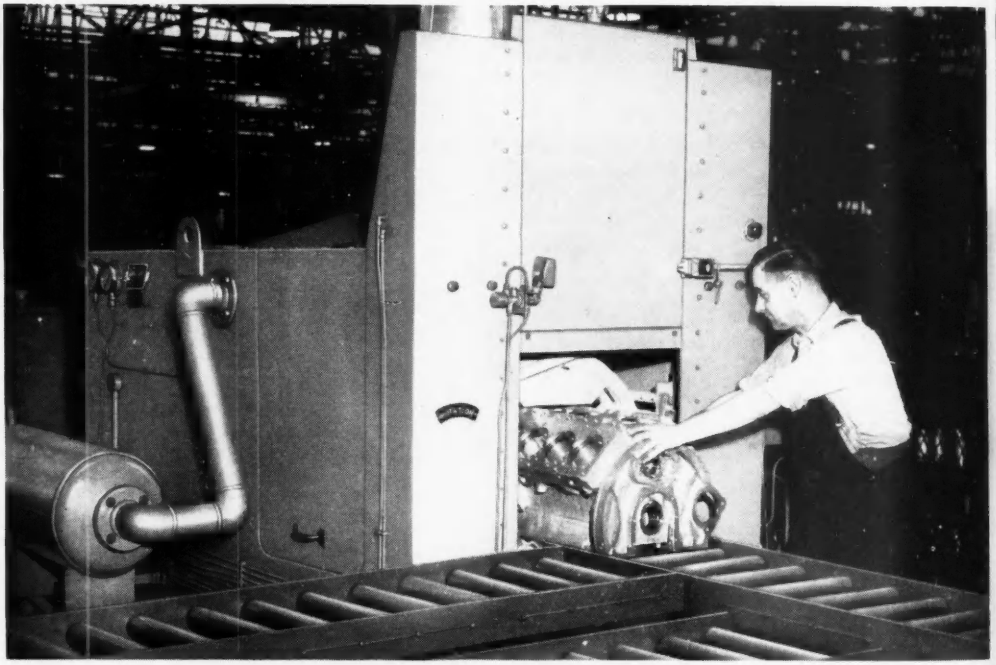

The aluminium alloy cylinder blocks of the Rolls-Royce Phantom V and Silver Cloud II are cleaned of swarf and cutting-oil after machining by this Dawson high pressure jetting machine. Inside the machine cylinder blocks are continuously rotated and as they move round they are subjected to an intense jetting treatment from batteries of jets accurately positioned so that no surface or recess, internal or external, escapes the powerful cleaning action. An important piece of equipment on the machine is the Dawson cylindrical pressure filter (patent pending). This is principly a perforated cylinder over which is fitted a finely woven nylon mesh bag, and the high fidelity filtration provided is particularly suitable for the very fine swarf produced in the machining of the aluminium alloy cylinder blocks.

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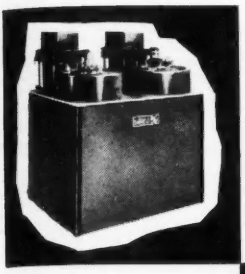
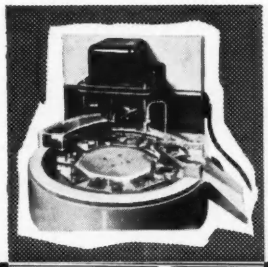
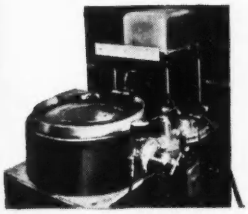
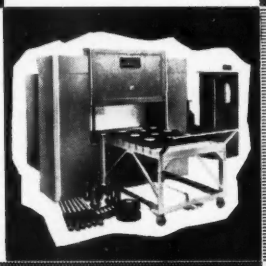


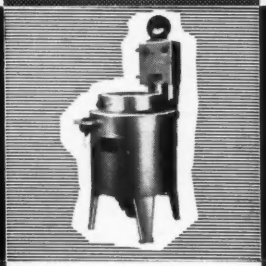
INDUCTION HEATING EQUIPMENT

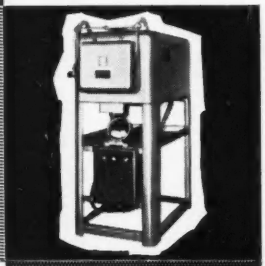


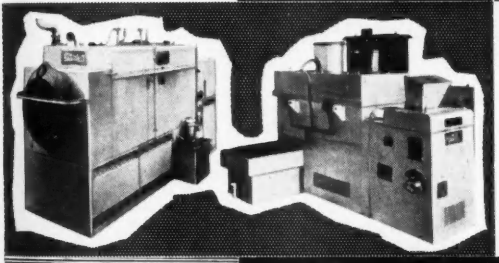


GENERAL PURPOSE FURNACES

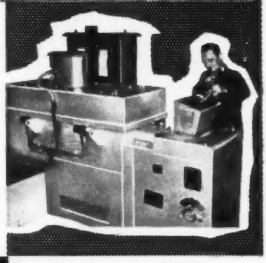


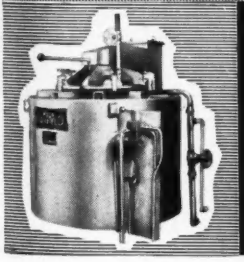


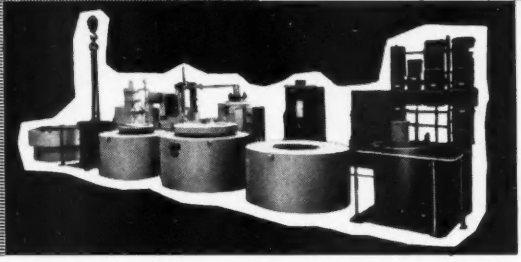




CONTINUOUS CARBO-NITRIDING FURNACES







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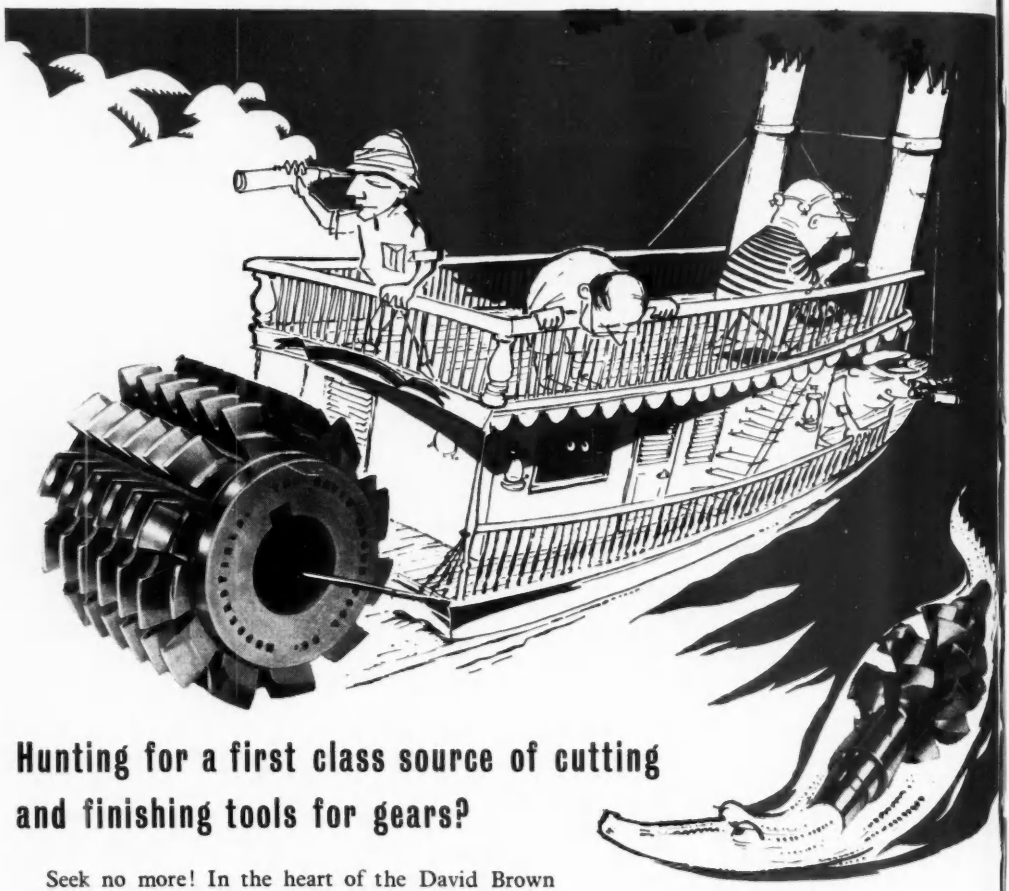

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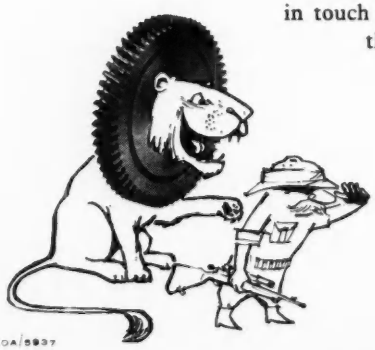

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THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *JOINING METALS BY DIFFUSION BONDING*

The production of a joint between two components with a controlled microstructure similar to that of the base metal of the components is important in certain critical applications. Special brazing alloys can sometimes be developed, but in many assemblies, such as atomic-reactor tube bundles, considerations of alignment and tolerance make it difficult to pre-place a brazing alloy, and welding is often impractical because of the close spacing of components.

In such cases, the answer to the problem may lie in developing suitable ways of diffusion bonding, in which one member of the joint is coated with an element that will form a eutectic with the base metal involved. The components are then placed in contact with the coated member, and the assembly is heated in a vacuum to a temperature higher than the eutectic temperature of the alloy system. A liquid eutectic composition will then be formed which acts both as the brazing alloy and as a diffusion bridge, the amount of liquid formed being controlled by the thickness of the metal coating.

The idea of using as a brazing alloy a eutectic composition formed at an interface is not entirely new. The new diffusion-bonding process, however, differs from earlier processes in several ways. Thus, attention has been given to using low-melting eutectics formed with the iron, nickel, or chromium already present in the alloy, the addition of any of these elements tending to lower corrosion resistance to a lesser degree than other elements that might be used. Also, as distinct from earlier processes, the added elements are not purposely diffused away and, because the microstructure of the diffusion-bonded joint can be carefully controlled, the same physical and mechanical properties can be obtained from every group of specimens of identical materials and dimensions.

From *Materials in Design Engineering*, U.S.A., April 1960, pp. 14–16.

● *SHEAR MODULUS OF FOIL HONEYCOMB SANDWICH STRUCTURES*

Aircraft structures require strong and rigid members of minimum weight, and increasingly high speeds call for further improvements in vibration and heat-proofing properties. It is for this reason that the use of sandwich structures has come into prominence. Sandwich structures are composed of core and facings, the core being made from lightweight materials, such as balsa wood, treated paper, foam rubber, or honeycomb metal-foil. The honeycomb structure is made from corrugated foil strips, bonded together over all longitudinal walls, so that these walls have double thickness as compared with the oblique walls of the honeycomb cells, and thin metal plates are fixed to the upper and lower surfaces of the core. In such composite constructions, the facing contributes mainly to extensional rigidity, i.e., flexural rigidity, and the core to shear rigidity.

Much work has been carried out on the elastic stability and the flexural rigidity of sandwich structures, but only a few investigations have been made with respect to the theoretical analysis of the shear modulus. In this connection, a recent Japanese paper is concerned with a study of the shear modulus of honeycomb structures as determined by the properties of the core materials, the geometry of the foil panels, and the flexural rigidity of the facings. In carrying out this analysis, some simplified assumptions regarding the stress system in the core have been made and, on the basis of these assumptions, a number of explicit approximate equations have been derived.

From *Transactions of the Japan Society for Aeronautical and Space Sciences*, No. 3, 1959, pp. 83–90.

● *HYDRO-SPARK FORMING OF METALS*

It has long been known that, when a condenser is electrically charged to the order of several thousand volts, the sudden discharge of the condenser across a spark-gap will produce a single pressure pulse or sound wave that propagates radially from the line of action of the spark. The high rate of propagation of this wave, initially exceeding the speed of sound in the particular medium, is responsible for a shock-wave of high energy, and, based on this knowledge, electrical discharges have been utilized to a limited extent in metal-working operations for more than fifty years.

The latest development is the electro-hydraulic or hydro-spark method of forming metals, which differs from electric-spark machining in the electrical circuits used and the physical processes and energy parameters involved. Also, electric-spark machining, which operates at a

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substantially lower voltage than hydro-spark forming, acts on the metal in a direct line from the electrode to the workpiece, while in hydro-spark operations, the force is perpendicular to the line of action of the spark.

If the liquid in which the spark takes place is dense and incompressible, the spark will heat the liquid to produce a gas which expands rapidly. Thus, a high transient pressure is produced, and the pressure created in the spark channel will be almost entirely transferred to the shock-wave with what is virtually an explosive-forming effect. Distilled water seems to be a satisfactory dielectric medium in which to produce the effect. The hydraulic impulse corresponds more or less to the shape of the current impulse, which, for the development of a short and intense hydraulic shock with a more pronounced shattering action, must be rapid, of high amplitude, and have a steep front.

Practical tests on hydro-spark forming indicate that it seems to be a convenient and powerful method of converting electrical to mechanical energy and that, as a metal-working tool, it has certain inherent advantages. Thus, apart from its simplicity, it appears to be superior to the conventional blasting materials used for explosive forming by virtue of its greater safety in handling and the ability to maintain more precise control over the energy produced.

From *The Tool Engineer*, U.S.A., March 1960, pp. 81–86.

● *REPLICA TECHNIQUE FOR STUDYING BRITTLE FRACTURES*

A recent report is concerned with an investigation into the applicability of electron microscopy for determining the relationship of the microstructure of ship-plate steel to its brittle-fracture transition temperature, in order to obtain a broader understanding of the phenomena involved in the brittle fracture of plating in ship's hulls under service conditions. The results obtained for a series of specimens of differing transition temperatures indicate that there is a relationship between the degree of separation of cementite lamellae and the temperature in the transition from predominantly ductile to predominantly brittle fracture, an increase in cementite ordering being correlated to higher transition temperatures.

The report includes details of a five-step procedure employed to obtain replicas for study. Briefly, this procedure consists of making a polystyrene negative replica, from which a silica positive replica is then obtained in a vacuum-evaporation unit. To effect shadowing of the silica replica, this is placed above a small graphite crucible containing a small quantity of germanium, which is used as the shadowing material, the plane of the replica being inclined 30 deg. to the line from its centre to the crucible. After evacuation to a pressure below 10^{-3}mm Hg, the crucible is heated by a cone of tungsten wire in which it is supported until an iridescent film of a purple colour is formed on the silica surface, the required time and temperature for the formation of this coloured film being of the order of 15 sec at 2700°C. Stripping of the silica-coated plastic is effected by immersing it in a solution of 85% ethyl bromide and 15% benzol until the polystyrene dissolves sufficiently to allow the silica film to be freed.

From *Report No. SSC–119*, Ship Structure Committee, U.S.A., January 11, 1960.

● *MEASUREMENT OF OIL-FILM THICKNESS IN GEAR TEETH*

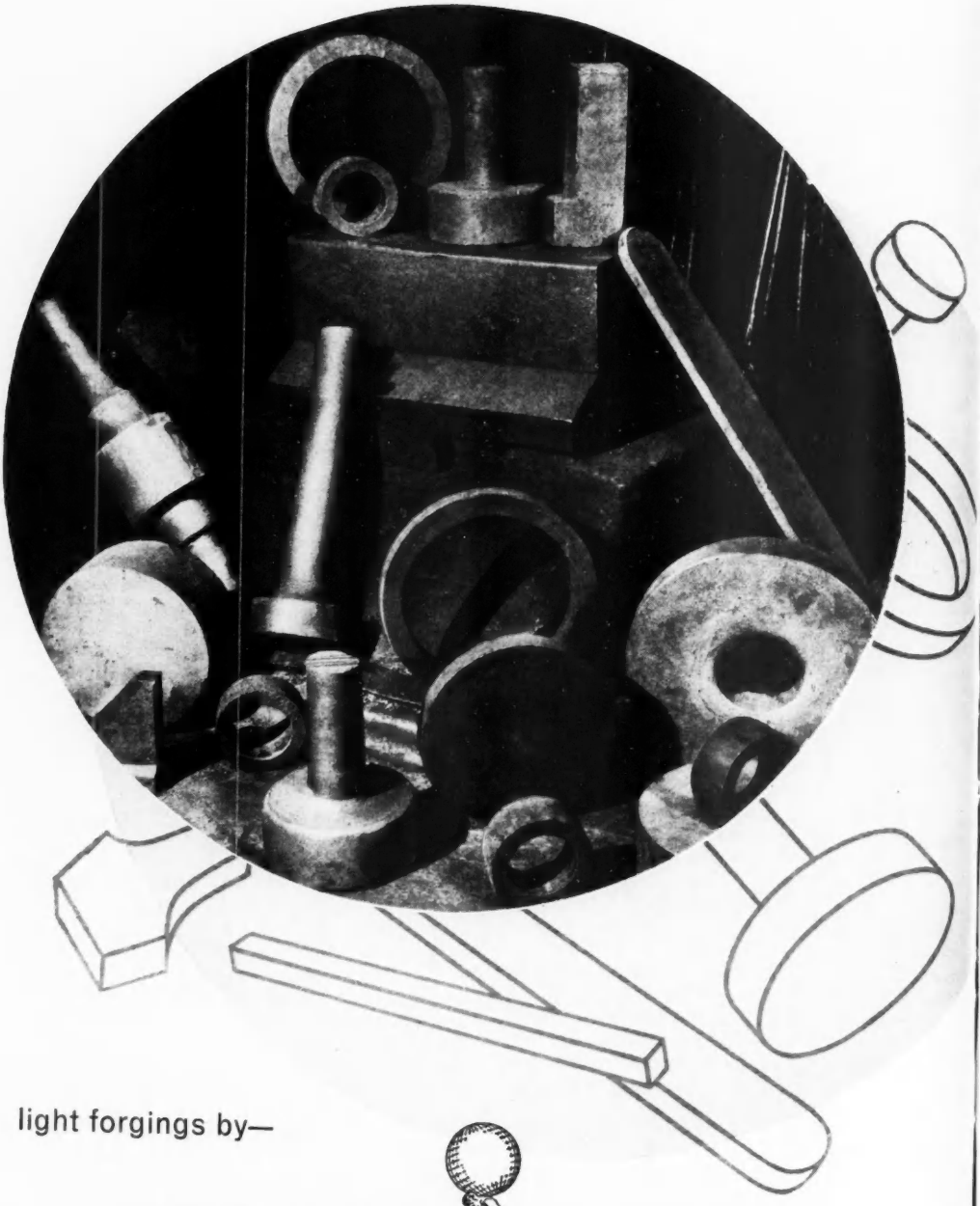
A major difficulty encountered in any research work on gears is the difficulty of getting near the line of contact and the consequent problem of making any measurements at this point. Many investigators have tried to use electrical resistance as a means of determining the type of lubrication occurring in gears, but it is generally recognized that it is impossible to obtain any quantitative data from these measurements. An experimental study of the passage of an electric current through a thin oil film shows that it very soon ceases to obey Ohm's law. As soon as the current reached about 0·5 A, the voltage drop across the oil film becomes independent of the current, the actual value of this discharge voltage varying with the thickness of the oil film.

Once the calibration constant of voltage against oil-film thickness has been determined, this method can be used for measuring oil-film thickness in any type of machinery, and a recent paper is concerned with its application to the measurement of the oil-film thickness between gear teeth. In this case, the voltage drop across thin oil films, through which a constant current of 1 A is passed, is used to measure the oil-film thickness between loaded gear teeth whilst in operation. It has been found that the thickness at the pitch line is between 0·0001 and 0·0004 in., the thickness varying slightly with viscosity and more strongly with loading. The thickness at the tips and roots is highly dependent on tip relief.

From *Trans. of the ASME, Journal of Engineering*, U.S.A., March 1960, pp. 29–34.

● *PRESSURE-POURING OF BILLETS*

In a recent article, the opinion is expressed that the new foundry method of controlled pressure-pouring can be modified to cast various semi-finished steel shapes, eliminating the need for soaking pits, blooming mills, and other expensive steel-plant equipment. In pressure-pouring, as, for instance, now in use by one firm for the casting of railway rolling stock wheels,



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air pressure is employed to force liquid metal from the ladle upwards through a refractory tube and into a permanent graphite mould. The ladle containing the molten steel is placed in an air-tight chamber and, as the air pressure in this chamber is increased, metal from the bottom of the ladle is forced upwards through the refractory pouring tube and into the graphite mould located above the chamber. When the mould cavity is filled, a refractory plunger shuts off metal flow, and the mould is removed from the chamber. Unused metal returns to the ladle, and the plunger, which is expendable, remains in the casting. Graphite moulds are used because the material has a low coefficient of expansion, permitting close dimensional tolerances on castings. The material has good thermal shock resistance, and mould cavities are easy to machine.

This method has been used to cast several semi-finished shapes in a variety of materials, such as stainless- and carbon-steel alloys, boron steels, and non-ferrous materials. Slabs, billets, and tube rounds, such as are used for making seamless tubes, have also been cast. Pouring and stripping are effected rapidly, a 30-ft billet, 4 in. square, being poured in about 10 sec, after which the mould can be removed in 4 to 5 min. Defects in the semi-finished shape are rare, and no scarfing or machining is necessary before rolling. Castings show some centre-line shrinks, but it appears that they are welded up satisfactorily during rolling.

From *Steel*, U.S.A., March 7, 1960, pp. 90 and 93.

● *THE "SPINCASTING" METHOD OF PRODUCING ACCURATE PARABOLIC REFLECTORS*

In designing large paraboloid antennas, the accuracy of reflector surfaces should not deviate from the ideal curve of a parabola by more than $\frac{1}{16}$th of a radio wavelength, e.g., $\frac{1}{2}$ to $\frac{3}{8}$ in. for a paraboloid to be used for a few hundred megacycles, and, although it has been practical to manufacture large paraboloids to these tolerances, their cost increases porportionally with the square of their size, so that requirements for new frequency bands cannot be met by present methods. It is for this reason that what is known as the "spincasting" process has been developed for providing a synthetic-resin face on large antennas, and it is reported that its use promises to improve surface accuracy by a factor of about 10.

The basis of the spincasting process is the natural phenomenon in which the surface of a pool of any liquid, spinning horizontally about a vertical axis, will, under the influence of centrifugal force and gravity, assume a paraboloidal shape with a focal length dependent on the rotational speed. The pool of liquid assumes its characteristic surface contour even if the bottom of the container is badly distorted, so that, if the container is a paraboloidal dish with its normal irregularities, the liquid would, in effect, smooth out the distortions and in this way increase surface accuracy. The problem has been to get the liquid to take a cast, but an answer has been found in the form of new synthetic resins, which are mixed in liquid form with a suitable catalyst just prior to spinning operations. As the liquid-resin surface assumes its shape, it gradually hardens until, at the end of the operation, it has become rigid. Theoretically, the spincasting surface should be a perfect paraboloid, but some surface deviation actually does occur owing to vibration of the spinning table, though irregularities are less then 0·005 in.

From *Mechanical Engineering*, U.S.A., March 1960, p. 86.

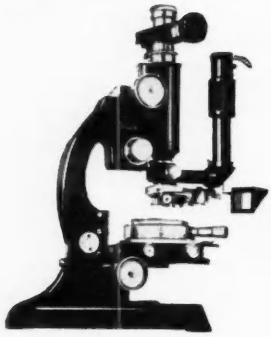
● *PRODUCTION OF FINE-PORE METAL FILTERS FROM CARBONYL POWDERS*

Usually, shaped porous elements are made simply by shaking the powder into a mould and subsequently sintering the moulded body. While filter plates produced in this way are quite suitable for purposes such as filtering salt melts, liquid metals, alkali and acid liquids, and dust-carrying waste gases, they are not fine enough to meet the exacting demands of processes such as the separation of isotopes in the gaseous form.

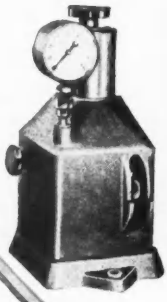
In this connection, a recently patented process is concerned with the production from carbonyl powders of fine-pored membranes and diaphragms for such purposes as the separation of isotopes from uranium by way of uranium hexafluoride. It has been found that shaped porous elements of uniform pore diameter can be produced if metal particles are deposited in a nascent state on perforated surfaces by the decomposition on the surfaces of metal carbonyls. The perforated surfaces, which are heated to or above the decomposition temperature of the carbonyl, can be metal plates or ceramic supports, optimum results being obtained with the use of a lattice or fabric on which the metal is deposited on one or both sides, e.g., a fabric having from 5000 to 20,000 meshes per square centimetre. Although the porous elements produced in this way have a mechanical strength which is too low for many purposes, it can be

For a further selection of items, please see our "Minidigest" section on pages A4, A6, and A8.

Micro Hardness Tester



Swirl
Electrolytic Polisher



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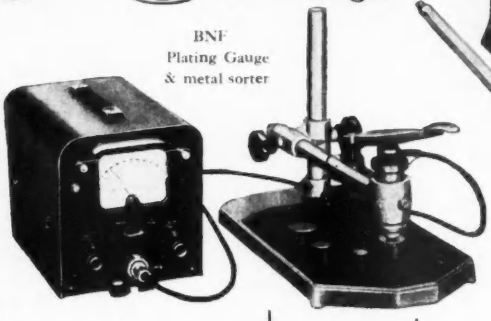

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improved by rolling, pressing, and sintering. For the decomposition of the metal carbonyl it has proved advisable not to use radiated heat, but to mix hot inert gases with metal carbonly vapour, these gases causing the decomposition. It is also possible to mix the metal carbonyl with cold gases prior to the decomposition with hot inert gases. In this way, the particle size of the deposited metal can be reduced and regularized. In order to avoid depositions on the wall of the reaction chamber used for the process, the wall temperature should be kept below the decomposition temperature of the carbonyl. The thickness of the layer produced on the heated surfaces is naturally dependent on the quantity of the carbonyl used, on the deposition period, and on the amount of inert gas employed.

From *Brit. Pat. Spec.* 832, 317.
Deutsche Gold- und Silber-Scheideanstalt vormals Roessler, Frankfurt, Germany.

● *GAS ANALYSIS OF METALS BY VACUUM FUSION*

In view of the increasingly critical specifications laid down for metals and alloys, it is becoming more and more important to measure the exact quantities of impurities present. Of these, gaseous impurities are particularly important, since hydrogen, nitrogen, and oxygen greatly affect the physical properties of metals.

Although analysis by vacuum fusion has been known for some years, it has only recently been applied to gas analysis on a production basis. The principle of vacuum-fusion gas analysis of metals is not complicated:— A representative sample of the metal is introduced into a high-vacuum system and is melted in a carbon crucible. As melting takes place, any gases present in the metal are released, and hydrides, nitrides, and oxides are decomposed. The released gases are pumped to another section of the system, where hydrogen is separated from the nitrogen and carbon monoxide. This can be effected in a variety of ways, one particularly effective method involving the use of a heated palladium tube which permits the passage of hydrogen but retains other gases. The amount of hydrogen isolated is then determined by measuring its pressure and volume. After measuring the pressure/volume ratio of nitrogen and carbon monoxide, the latter is then catalytically transformed into carbon dioxide and is absorbed from the gas stream.

This system is so sensitive that as little as 0·0002% of gas content can be determined. Hydrogen and oxygen values can be determined with reasonable accuracy, but nitrogen values are considered to be unreliable, because nitrogen escaping from the molten metal tends to combine with the cooler metal further up the sides of the crucible. At this point, nitrogen analyses give lower values than the true values and, on further heating, the recombined nitrides may decompose, releasing quantities of gas which may be either higher or lower than the amounts actually present.

From *Iron and Steel Engineer*, U.S.A., March 1960, p. 137.

● *IMPROVEMENTS IN THE MACHINING OF TITANIUM AND ITS ALLOYS*

Titanium and some of its alloys are liable to harden on diffusion of certain gases and liquids when the material is heated at the shear planes as a result of the action of shearing and/or friction produced in the machining process. This hardening will, for example, take place when the metal is being machined at a high speed in air, by absorption of oxygen and nitrogen, and also when the tool is cooled by carbon dioxide. If the coolant gas enters along the face of segregation of chip and stock, it dissociates into its elements to form carbide and oxide traces with titanium and aluminium. This hardening process will persist during the period of machining and will cause rapid breakdown of the cutting edge of the tool.

Hardening can, however, be prevented by maintaining a non-hardening or neutral gas or other protective layer at the cutting point. This protective layer may consist of argon, which can be applied to the cutting zone in the form of a jet. Alternatively, the protective layer may be produced from a mist or spray, which will deposit liquid upon the part to be machined so as to form a hardening-inhibitive film on it. The mist may be formed in a non-hardening or neutral gas, the suspended phase of the mist being formed from a solution of sodium nitrite, sodium silicate, sodium chloride, or a mixture of these gases. In cases where a sodium nitrite solution alone is used to form the mist, its concentration may be 5% or higher. Alternatively, the suspended phase may consist of a neat cutting oil or of water-soluble oil mixtures. It is claimed that improved machinability and surface finish are obtained, since higher machining speeds can be employed which, by raising the temperature of the metal at the cutting point, reduce its shear strength and thereby facilitate the cutting process.

From *Brit. Pat. Spec.* 827, 364.
The Minister of Supply, London.

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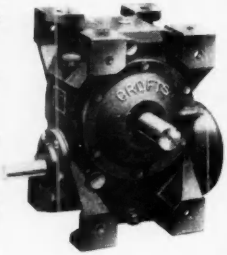

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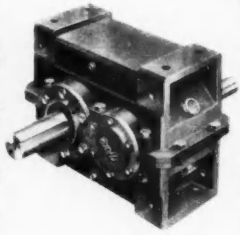

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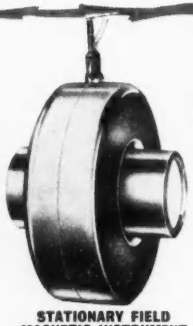

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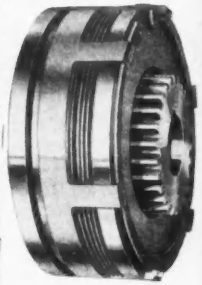

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THE ENGINEERS' DIGEST

A World Review of DESIGN & PRODUCTION—RESEARCH & DEVELOPMENT

VOL. XXI No. 5 MAY, 1960

The Selection of Metals for Low-Temperature Use

By O. A. HANSEN

From *Mechanical Engineering* U.S.A.,
Vol. 82, No. 4, April 1960,
pp. 60–62, 4 illustrations.

METALS are grouped according to the arrangement of the atoms in the crystals, i.e., whether they have a face-centred cubic lattice, a body-centred cubic lattice, or a hexagonal lattice. Metals which have a cubic lattice with an atom in the face of each surface show no loss of ductility at low temperatures, while those which are body-centered or have a hexagonal lattice show a marked tendency to brittleness at temperatures below a transition range. Hexagonal-lattice materials, such as titanium and magnesium, are similar to body-centred metals, except that the transition temperature is well above room temperature, and hence the material behaves as if it had no transition-temperature range when used for low-temperature work. It should be noted that the ductility of face-centred metals improves at low temperatures, while that of iron (a body-centred cubic-lattice material) falls to a very low value. Fortunately, iron can be alloyed in such a way that the reduction in ductility is not so severe.

Initially, copper (a face-centred cubic-lattice material) was the most widely used for low-temperature work, because its formability and the ease of making joints with soft solder made it a natural metal for the construction of experimental equipment. When this experience was carried into the commercial field, the drawbacks of low strength and the unreliability of soft-soldered joints were emphasised.

The ultimate strength and yield point of copper have been increased considerably by alloying, as, for example, to obtain the $3\frac{1}{2}\%$ silicon alloy. The values at room temperature for the annealed state are an ultimate strength of 62,000 psi, compared with 33,000 psi for pure copper, and a yield point (0·5% offset) of 21,000 psi, compared with 8000 psi for pure copper. Reduced temperatures tend to improve the properties of the alloys to about the same extent as for the base metal.

Because production facilities have increased and prices have been lowered, aluminium (another face-centred cubic-lattice material) has been much more widely used for low-temperature service. In its pure state, it has easy-working characteristics, but is not very strong. All the aluminium alloys, as well as pure aluminium, are ductile at low temperatures; in addition, they are non-corrosive and easy to fabricate. For most pressure-vessel work, alloys must be weldable and, until recently, the strongest weldable aluminium alloy had an ultimate strength of only 25,000 psi. Since these alloys were one-third as heavy as stainless steel and only one-third as strong, and cost approximately the same on a weight basis, there was not much incentive for their use. The heavier gauges required with aluminium increased welding costs and proper welding procedures did not exist.

There are now standard procedures, including welder training and rigid control of cleaning procedures and weld design, which ensure sound joints. Also, the development of new weldable alloys with an ultimate tensile strength of 30,000 psi and even newer alloys in the 40,000- and 42,000-psi range, further brightens the outlook for this metal. However, the fatigue limit of all aluminium alloys when welded is only 5000 to 10,000 psi after a few million cycles.

Of other face-centred cubic-lattice materials, the austenitic stainless steels, if kept in the austenitic state by proper heat treatment and composition (e.g., low carbon content), are excellent at low temperatures. The low-temperature toughness of the base metal may drop if the metal is cold-worked, or if the carbides have separated because of improper heat treatment. Even under somewhat adverse conditions, toughness is comparatively high, with Charpy impact values of 30 to 50 ft-lb.

In order to ensure welds of satisfactory ductility and toughness (normally much lower than for base metal) alloys having a high carbon content are not used. Type-347 stainless steel is not quite as bad, but weld toughness is border-line. Welds in 304 stainless steel are heat-sensitive and are deleteriously affected unless the proper filler metal is used. For example, if postweld heating is encountered, as from a brazing process, the Charpy-keyhole toughness of a standard 308 electrode weld may drop to as low as 5 to 10 ft-lb. For this reason, stainless steel should not be stress-relieved in the carbide-precipitation range (850 to 1600°F). Little value is obtained below 850°F, and distortion and improper cooling may be found at the higher temperatures.

It is interesting to note the transformation of the austenitic stainless steel to the martensitic form after prolonged exposure to very low temperatures. Thus, one end of the stem of a valve used in liquid-oxygen service for several years had been at room temperature all the time and showed no magnetic properties, while in the cold end there was sufficient martensite to hold a magnet. The author knows of no failure which can be attributed to this conversion to martensite. Even where it is appreciable, there is no great loss in ductility.

In the body-centred cubic-lattice group, iron and steel are the most common metals and are the most generally used construction materials. However, they must be specially alloyed for use at low temperatures and, for most applications, alloying must be extensive.

These materials have a transition range in which the material changes from ductile to one which is markedly notch-sensitive and which fails with a brittle fracture. The strength increases at low temperature, but the notch

sensitivity is such that the performance at temperatures below the transition range is generally unpredictable. If there were complete assurance that the material could be free of notches and stress raisers, the high strength of low-alloy steel might be used effectively, even at very low temperatures.

One example of the satisfactory use of low-alloy steel at very low temperatures is found in wires used in pre-stressed concrete for large liquid-oxygen storage tanks. The wire, which is wrapped around the concrete tank, is of 0·162-in. diameter, cold-drawn to 0·142-in. diameter during application, imposing a stress of 140,000 psi in the wire. The drawn wire has a tensile strength of 230,000 psi at room temperature and 300,000 psi at liquid-oxygen temperature. Although the elongation is only about 2% in 10 in. at liquid-oxygen temperature, several test specimens have been bent at over 90 deg. before fracture.

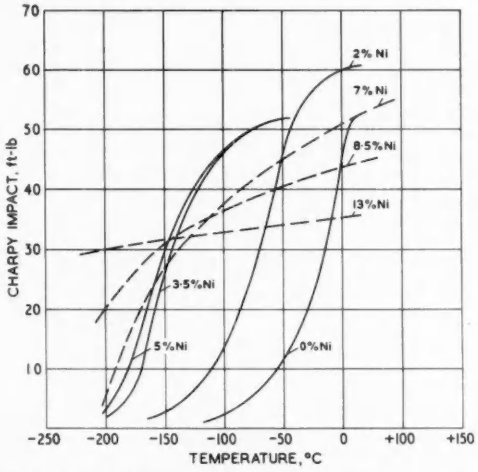

Fig. 1. Impact strength as a function of temperature for steel alloyed with different amounts of nickel.

With regard to nickel-steel alloys, the general effects of alloying various amounts of nickel with steel are shown in Fig. 1. The transition range moves to lower and lower temperatures with increasing nickel content, and the residual ductility is somewhat higher. When the nickel content is raised to 8·5%, however, the transition temperature drops to below −195°C, and the alloy has characteristics quite unlike the lower alloys. It becomes a material quite well-suited for low-temperature work, but there may be some unusual problems encountered in its use. A steel containing 9% nickel has a permissible working stress of 22,500 psi, except where the weld-metal stress is limiting.

Cast iron has very little ductility at room temperature, and loses about half of its ductility at low temperature, although alloying with nickel permits retention of more ductility. With its many graphite inclusions, it is so full of notches that the effect of extraneous notches goes unnoticed. Many cast irons show a tendency to increase in volume after being subjected to very low temperatures. Data exist to show that a crack cannot be initiated or propagated, even in brittle material, if the stresses are below 6000 to 10,000 psi.

Piping Flexibility

Changes in material characteristics can introduce many new variables in the computations for stresses occurring because of reduced temperature. The modulus of elasticity increases somewhat at low temperatures, but the effect is not serious, because the thermal expansion is reduced.

There is another factor, however, which must be taken into consideration, i.e., that low-temperature equipment is usually constructed at the midpoint of the temperature range, the material being heated after fabrication for drying, before being subjected to low-temperature operation. This makes it impossible to use "cold-springing" at room temperature to limit the maximum stress at the operating temperature.

Solders

The ready availability of copper in tubing form extended its use for piping long after pure copper had been superseded by alloys or other metals for pressure-vessel components, and soft solder (equal parts of lead and tin) continued to be used at the joints, although improved silver solder and brazing techniques have now made it obsolete for low-temperature work for both copper and copper alloys.

A simple but major development in the hard-solder joint in piping has been the establishment of a short overlap. When the fittings employed for soft-solder connections are used with silver brazing, either the joint is overheated or it contains a trap. With an overlap of only ⅛ to ¾ in., the silver solder can be "flowed through" to make a pocketless joint without burning the piping. This does away with the possible wedging open of the joint from the continued freezing and thawing of moisture retained in the joint.

An early source of much trouble was the lead content of many of the cast fittings used for soft-soldered piping. Silver brazing on these fittings would not be successful because the lead would separate and contaminate the brazing alloy and result in cracking.

Joining Aluminium to Stainless Steel

In the Proceedings of the 1959 Cryogenic Engineering Conference, four methods of joining aluminium to stainless steel were described by Smith and Rabb. All these methods are aimed at means of tinning the aluminium, so that a subsequent soldering operation can be carried out between two compatible metal surfaces, and comprise joining (a) copper-plated aluminium to stainless steel, (b) ultrasonically tinned aluminium to stainless steel, (c) friction-tinned aluminium to stainless steel, and (d) aluminium to copper to stainless steel.

In all cases, the solder is subjected to severe stresses by any change in temperature because of the extreme difference in thermal expansion of the two base metals. If the solder layer is too thin, there is so much resistance to flow that the stresses may be extreme. If the solder layer is thick, it may present problems because of its own inherent weakness. The use of a mechanical joint to relieve the solder from stress, with the solder acting as a seal, makes a satisfactory arrangement.

Several new methods are being developed to join aluminium to other metals. Thus, the refrigeration industry uses flash-welding of copper and aluminium tubes, while the "Al-Fin" process casts a layer of aluminium on a "pretinned" part made of some other metal. The commercial product, copper-clad aluminium, can be used as an intermediate part, with aluminium welded to the aluminium part and copper or steel to the other part. It is necessary in this case to strip the opposite metal from the area near the joint to prevent contamination.

The Interpretation of Rheological Data for Engineering Use

By G. W. GOVIER

From *The Engineering Journal*, Canada,
Vol. 43, No. 3, March 1960,
pp. 79–84, 6 illustrations

RECENT developments and full-scale applications of the pipeline transport of suspended solids and applications of "heavy media" to mineral-ore processing and of suspended-solids systems as heat-transfer media require an appreciation of the effect of concentration and other variables on the consistency or "viscosity" of such mixtures. This article is intended to acquaint the non-rheologist with a few of the basic concepts of rheology, with the calibration and use of rotational viscometers, and with a method of data interpretation which the author has found useful in engineering applications.

Fluids can be classified into several rheological types, according to their behaviour when subjected to shearing forces of such a magnitude as to cause laminar or non-turbulent motion of the fluid. By convention, the unit shearing stress dF/dA is compared with the rate of shear or the velocity gradient developed at right-angles to the applied stress dV/dX. Typical shearing stress/rate of shear curves for fluids, which, while behaving similarly at one particular rate of shear, exhibit a different behaviour at other rates of shear, are given in Figs. 1 and 2.

In the case of most liquids and all gases, the rate of shear developed is found to be directly proportional to the unit shearing stress applied, and can be expressed as

$$dF/dA = (\mu/g_c)dV/dX \quad .. \quad .. \quad (1)$$

where μ is the constant of proportionality known as viscosity, and g_c is a dimensional conversion factor.

A fluid whose rheological behaviour is described by eq. (1) is known as a Newtonian fluid, and a single quantity, i.e., viscosity, gives a complete description of its rheological behaviour. Since viscosity itself is defined by eq. (1), it is clear that only a fluid which behaves in accordance with this equation can be considered to exhibit the property of viscosity. Interpretation of the Newtonian line in Fig. 1 indicates that the viscosity of a Newtonian fluid is expressed by the slope of the line in arithmetic co-ordinates, this line necessarily being a straight line through the origin. In logarithmic co-ordinates (Fig. 2) the Newtonian fluid exhibits a straight line with a slope equal to 1.

Certain fluids, notably those of complex compositions or those which are really physical mixtures, do not exhibit this simple relationship when the unit shearing stress is plotted against the rate of shear. These fluids are called non-Newtonian. Some such systems yield a complex shearing stress/rate of shear curve which cannot be described simply. Among the simpler cases, however, are the Bingham plastic and the pseudo-plastic. The Bingham plastic is defined as a material for which a finite shearing stress is required to initiate shear, and for which there is a linear relationship between all greater unit shearing stresses and rate of shear. The Bingham plastic is defined mathematically as

$$\frac{dF}{dA} - \tau_y = \frac{\eta}{g_c}\frac{dV}{dX} \quad .. \quad .. \quad (2)$$

where τ_y is the yield of the material corresponding to the unit shearing stress required to initiate motion, and η is the coefficient of rigidity.

The relationship between unit shearing stress and rate of shear for a Bingham plastic is also indicated in Figs. 1 and 2. The intercept on the unit-shearing-stress axis in Fig. 1 corresponds with the yield value τ_y, and the slope of the straight line is the coefficient of rigidity η. On the logarithmic co-ordinates in Fig. 2, the Bingham plastic exhibits a curve convex to the rate-of-shear axis, approaching zero slope at low shear rates, and a slope of one at high shear rates. Relatively few materials have been found to exhibit true Bingham plastic behaviour and

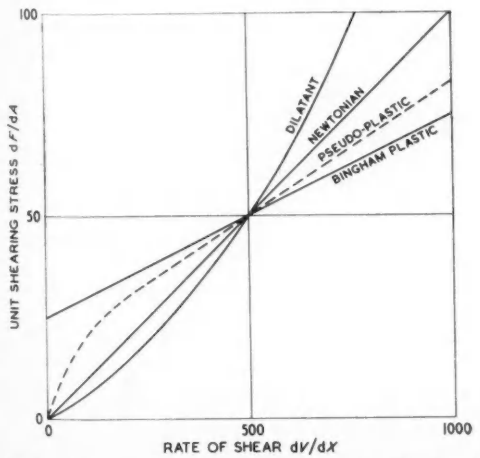

Fig. 1. Arithmetic plot of unit shearing stress as a function of rate of shear.

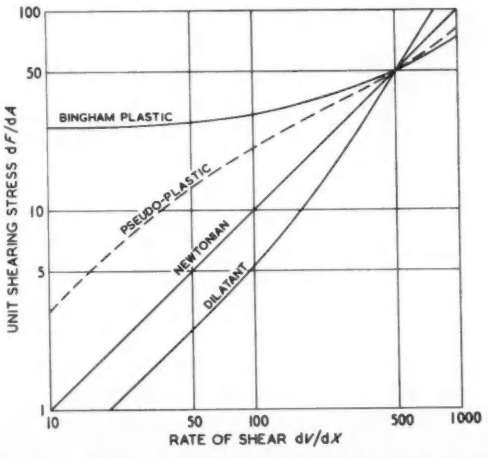

Fig. 2. Logarithmic plot of unit shearing stress as a function of rate of shear.

this rheological type is important chiefly in that it serves as a limiting case for the pseudo-plastic type.

The line for pseudo-plastic materials passes through the origin and is curved convex to the shearing-stress axis up to a certain shearing stress, but is approximately linear with the rate of shear beyond that point, as can be seen from the arithmetic plot in Fig. 1. On the logarithmic co-ordinates in Fig. 2, the pseudo-plastic yields a relationship similar to that of the Bingham, except at low rates of shear. It will be apparent that, at high rates of shear, pseudo-plastics behave much like Bignham plastics; thus, they are occasionally characterized by an " apparent coefficient of rigidity " and an " apparent yield value ". The apparent coefficient of rigidity if equal to the slope of the near-linear part of the curve on the arithmetic co-ordinates, and the apparent yield value is equal to the intercept formed by linear extrapolation of the line to zero rate of shear.

Among several other types of non-Newtonian fluids, less commonly encountered, is the dilatant fluid whose characteristics are also included in Figs. 1 and 2.

The widespread use of the term " viscosity " as a measure of consistency has led to its incorrect use in the case of Bingham plastics, pseudo-plastics, dilatant fluids, and other rheological types. Since the viscosity of a Newtonian fluid is proportional to the ratio between the unit shearing stress and the rate of shear, the term viscosity has been applied to this same ratio in the case of non-Newtonian fluids. It is clear from Fig. 1, however, that this ratio varies at different rates of shear, indicating different consistencies. These different consistencies should not be referred to as viscosities, but may usefully and accurately be called " apparent viscosities ".

Thus, while a Newtonian fluid is rheologically characterized by a single quantity, i.e., viscosity, the Bingham plastic and other rheological types are sufficiently complex to require more than one quantity to describe their rheological behaviour. Alternatively, the rheological properties of these latter materials may be described by a series of apparent viscosities spanning the range of rates of shear of interest. This latter method has found favour because of the similarity of meaning and the identity of units and dimensions of apparent viscosity and viscosity.

The Rotational Viscometer and its Calibration

Of the many different types of viscometers available, the concentric-cylinder instrument is probably the simplest of the designs really useful for the study of non-Newtonian fluids. This instrument consists essentially of an inner and an outer cylinder so arranged that, with the fluid to be tested in the annular space between the cylinders, one of the cylinders can be rotated, while the torque transmitted through the fluid to the other stationary cylinder is measured in some way.

For use with a Newtonian liquid, the relationship between the rate of shear at the stator wall and the rotor speed for such a rotational viscometer may be determined mathematically from the Reiner-Riwlin[1] equation

$$\frac{dV}{dX_r} = \frac{4\pi R_1^2 R_2^2}{r^2(R_2^2 - R_1^2)} N \quad .. \quad (3)$$

Where dV/dX_r is the rate of shear at the stator wall [sec^{-1}], R_1 is the inner and R_2 is the outer radius of the annulus, r is the radial position at which the shear rate is given when $R_1 < r < R_2$, and N is the rotor speed [rps].

If the outer cylinder is rotated and the torque on the inner cylinder is measured, it is the rate of shear at the wall of the inner cylinder that is of interest.

Substituting R_1 for r,

$$\frac{dV}{dX_{R1}} = \frac{4\pi}{1 - 1/s^2} N \quad .. \quad .. \quad (4)$$

where $s = R_2/R_1$. This equation relates the rate of shear of interest to the system geometry and the rotational speed.

The relationship between the deflection of the spiral spring, or other torque-measuring device, and the unit shearing force at the stator wall is best determined by calibration. This can be done readily by obtaining speed-deflection data for a true Newtonian liquid of accurately known viscosity. A linear relationship between deflection and unit shear stress may be assumed, viz.,

$$\frac{dF}{dA_{R1}} = K\theta \quad .. \quad .. \quad .. \quad (5)$$

where dF/dA_{R1} is the unit shear force [dynes/cm^2] in the liquid at the wall of the inner cylinder (stator), θ is the deflection of the torque-measuring device [degrees or divisions], and K is a factor of proportionality.

With measured values of N and θ, and the viscosity of the calibrating liquid, a simple solution of eqs. (1), (4), and (5) will yield values of K. A well designed instrument will yield the same value of K for any Newtonian liquid at any operating speed N, so long as laminar flow conditions prevail in the annulus.

Data Processing and Interpretation

Eqs. (4) and (5) constitute the calibration equations for a rotational viscometer for use with any Newtonian liquid. The Reiner-Riwlin equation (3), on which eq. (4) is based, is strictly applicable only when the annular fluid is Newtonian.

For a non-Newtonian fluid, the rate of shear at the stator wall is expressed by the more general Krieger-Maron[2] equation

$$\frac{dV}{dX_{R1}} = \frac{4\pi}{1 - 1/s^2} NF \quad .. \quad .. \quad (6)$$

In this equation, F is the Krieger-Maron correction factor and is expressed by

$$F = 1 + k_1\left(\frac{1}{n''} - 1\right) + k_2\left[\left(\frac{1}{n''} - 1\right)^2 + \frac{d(1/n'' - 1)}{d \log_e \theta}\right]$$

where $k_1 = \frac{s^2 - 1}{2s^2}\left(1 + \frac{2}{3}\log_e s\right)$,

$$k_2 = \frac{s^2 - 1}{6s^2}\log_e s,$$

and n'' is the slope of θ plotted against N on a log-log graph.

Often, the final term in the Krieger-Maron correction factor is relatively small and may be neglected.

Thus, for use with a non-Newtonian fluid, the basic equations for interpretation of data are eq. (5) with the value of K determined with the aid of eq. (1) from a Newtonian calibration, and eq. (6) with the value of F determined from a log-log plot of θ versus N. Although much data in the literature have been based on the use of eq. (4), instead of the more recently developed eq. (6), the error is relatively small as, in most cases, the F factor is not too much greater than unity.

For ordinary applications in a thorough investigation of the rheological characteristics of a fluid, θ values

should be determined over a wide range of rotor speeds corresponding to rates of shear from below 10 to about 1000 sec $^{-1}$. Determinations should be made at controlled temperatures and under laminar-flow conditions. The raw θ-N data are conveniently plotted on multicycle log paper for preliminary smoothing and Krieger-Maron processing. Derived (dF/dA) and (dV/dX) data are also conveniently plotted on multicycle log paper, from which the extent and kind of non-Newtonian behaviour is clearly apparent.

A technique found by the author to be extremely useful is to plot the final results as (dF/dA) + 0·1 versus (dV/dX) + 0·1 on at least 5-cycle logarithmic paper. The addition of the small constants permits the 0·1, 0·1 co-ordinates to serve as the origin of co-ordinates with respect to (dF/dA) and (dV/dX) themselves. In this way, data can be extrapolated to the origin in the many cases where pseudo-plastic behaviour is encountered. The utility of the plot is further enhanced by drawing in the lines corresponding with Newtonian fluids of 1, 10, 100, 1000, and 10,000 centipoises. Beyond the first two cycles of both co-ordinates these lines appear as straight lines with a slope of 45 deg. and serve as a third scale from which viscosity, apparent viscosity, and coefficient of rigidity can be read directly for the system for which test data are plotted.

If on such a plot the data form a curve which asymptotically approaches a horizontal line at low rates of shear and a 45-deg. line at high rates of shear, Bingham-plastic behaviour is indicated. The yield value τ_y can be read directly from the ordinate by extrapolating the horizontal portion of the curve, and the coefficient of rigidity directly from the position of the 45-deg. line with respect to the "third scale". Moreover, apparent viscosities at any rate of shear can be read directly from the intersection of the data-point curve with the third-scale lines of constant apparent viscosity.

More commonly, the data for systems of engineering interest will form a curve indicating pseudo-plastic behaviour. Assuming such a behaviour, the curve can be extrapolated to zero rate of shear, using as a general guide the curves of the Newtonian fluids. If necessary, the data can also be extended to higher rates of shear by trending the curve asymptotically to a 45-deg. straight line. From such an extended curve apparent viscosities can be read directly for any rates of shear of interest.

Frequently, it is convenient to represent pseudo-plastics in an approximate manner by treating them as though they were Bingham plastics and assigning to them apparent yield values and apparent coefficients of rigidity. Such a procedure is often justifiable when the flow behaviour at relatively high rates of shear is of major interest. There are various ways of obtaining these apparent properties, one being from an arithmetic plot of (dF/dA) versus (dV/dX). In this case, the apparent yield value is obtained by linear extrapolation to zero rate of shear of the near-linear portion of the curve. The apparent coefficient of rigidity is obtained from the slope of the near-linear portion of the curve.

Another method[3] of obtaining the apparent coefficient of rigidity is to plot the ratio of (dF/dA) to (dV/dX) (which is the apparent viscosity) versus (dX/dV) and to extrapolate to zero (dX/dV) or infinite (dV/dX).

A third way of obtaining the apparent properties is from a logarithmic plot either of (dF/dA) versus (dV/dX) or of (dF/dA) + 0·1 versus (dV/dX) + 0·1. In this case, the apparent yield value is obtained by horizontal extrapolation of the experimental curve from the convex to concave inflection point. The apparent coefficient of rigidity is obtained by extrapolation of the high rate-of-shear portion of the curve asymptotically to the limiting 45-deg. straight line.

None of these methods has any fundamental advantage over the others, because the apparent properties have little fundamental significance in any case. The author uses all these methods, but favours the last-mentioned, especially when dealing with a family of curves for related mixtures.

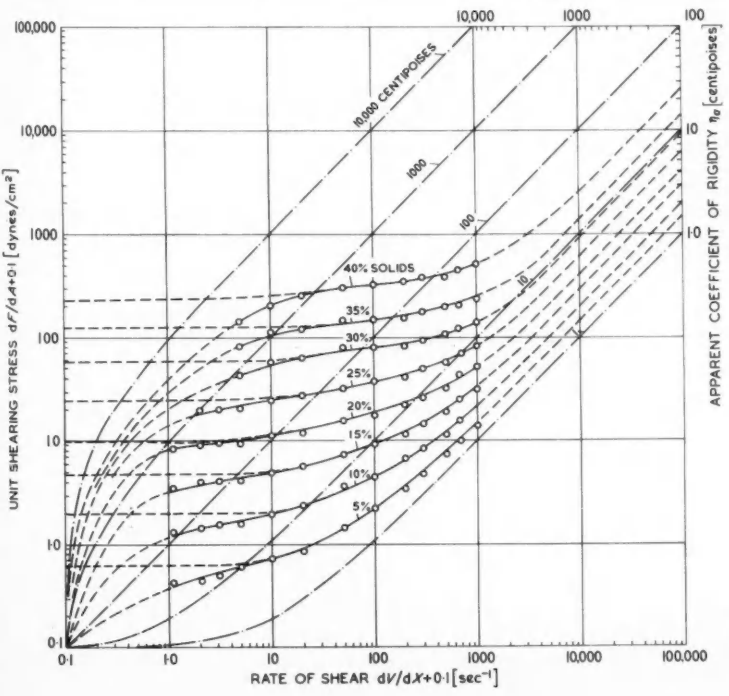

Fig. 3. Modified logarithmic plot of typical unit shearing stress as a function of rate of shear for different suspensions of clay in water.

To illustrate data interpretation on a modified logarithmic plot, typical (dF/dA) and (dV/dX) data for a series of clay-water suspensions are given in Fig. 3, which indicates that all these suspensions behave as pseudo-plastics, but that, at rates of shear above about 10 reciprocal seconds, their behaviour approaches that of Bingham plastics. Fig 3. permits ready extrapolation of the data to zero and to high rates of shear. Thus, the heavy curves through the data points and the broken-line extensions give a good representation of the rheological behaviour of the suspensions over a wide range of rates of shear.

Apparent yield values and coefficients of rigidity can be obtained by the methods described. The apparent coefficients of rigidity can also be determined by the reciprocal extrapolation method. A comparison of the apparent properties as determined by the various methods described shows that there are some differences in the results. These are due to differences in interpretation and are a measure of the inaccuracies inherent in all methods. Since the suspensions are not really Bingham plastics, none of the interpretations is really correct, though each represents the data about equally well.

Returning to Fig. 3, it can be seen that rheological performance can be estimated over substantially all rates of shear, and that real or apparent yield values and coefficients of rigidity can be read directly from such a plot. Apparent viscosities can be read at any shear rate merely by observing where the data line at that shear rate cuts the third scale.

For an appreciation of the rheological nature of a system, consider, for example, the line for the 10% clay-water suspension and compare it with the 1-centipoise or 0% clay-water line in Fig. 3. The nature of the system precludes the existence of a true yield value, and the data line is extended to zero shear rate—as for water itself. At shear rates of 1 to 10 sec^{-1}, unit shearing stresses about 10 times as great as for water are required for the clay-water system. The shear stress increases with increasing shear rate, but more slowly than for water; at 100 and 1000 sec^{-1}, the comparative shear stresses are respectively about 4·5 and 2·3 times those for water. The extension of the data line to the right indicates an asymptote of 1·9 centipoises. This is the apparent coefficient of rigidity of the suspension or its apparent viscosity at high rates of shear. Extending the convex portion of the data lines to the left indicates an apparent yield value of about 1·8 dynes/cm^2. In other words, if it were desired to approximate the behaviour of the suspension by the two Bingham constants, these values would be appropriate and the actual rheological behaviour would be fairly closely represented for all shear rates above 10 sec^{-1}.

In terms of apparent viscosities, it can be observed directly that the apparent viscosity of the 10% suspension is above 100 centipoises at extremely low rates of shear, decreasing to 10 centipoises at a rate of shear of 25 sec^{-1}, to 5·5 centipoises at 100 sec^{-1}, to 2·2 centipoises at 1000 sec^{-1}, with a limiting value of 1·9 centipoises at very high shear rates.

The Application of Rheological Data

Rheological data are required for the design of systems for the pumping, transportation, mixing, and heating of non-Newtonian fluids, for the settling of particles in them, and in all cases where the consistency of the fluid is important. The commonest application is to pipe-line transportation and to the calculation of pressure-drop/flow-rate relationships as functions of line size and fluid properties. For Newtonian fluids, the procedures are now well established for both laminar and turbulent flow conditions. Much less is known for non-Newtonian fluids, although methods have been developed for dealing with simple cases.

For a true Bingham plastic in laminar motion, the Buckingham equation given below has both theoretical and experimental backing.

$$\frac{8V}{D} = \frac{g_c}{\eta}\left[\frac{D\Delta P}{4L} - \frac{4}{3}\tau_y + \frac{1}{3}\frac{\tau_y^4}{(D\Delta P/4L)^3}\right]$$

where V is the average velocity in ft per sec, D is the pipe diameter in ft, η is the coefficient of rigidity in pounds (mass) per ft per sec, $g_c = 32{\cdot}2$ pounds (mass) feet per pound (force) per sec^2, L is the length of the pipe in ft, τ_y is the yield value in pounds (force) per sq ft, and ΔP is the pressure drop in pounds (force) per sq ft.

This equation can be rearranged in several ways. Thus, Govier and Winning[4] have demonstrated by dimensional analysis that, for Bingham plastics, the friction factor f can be expressed as a function of a modified Reynolds number $R_m = (DV\rho)/\eta$ and of a "yield number" $Y = (D\tau_y g_c)/V\eta$, in which case the Buckingham equation becomes

$$\frac{1}{R_m} = \frac{f}{16} - \frac{Y}{6R_m} + \frac{Y^4}{3f^3R_m^4}$$

where the friction factor $f = (g_c D\,\Delta P)/2V^2L$.

Perkins and Glick[5] have rearranged the Buckingham equation to the form

$$\frac{1}{R_m} = \frac{f}{16} - \frac{H}{6R_m^2} + \frac{H^4}{3f^3R_m^8}$$

$$\text{where } H = YR_m = \frac{\tau_y D^2 \rho g_c}{\eta^2}$$

which is a dimensionless ratio suggested by Hedstrom[6], who has also prepared a graphical representation of the Buckingham equation in the form of f versus R_m with H as a parameter.

It is of interest to compare these re-arranged forms of the Buckingham equation with that for Newtonian fluids, i.e.,

$$\frac{1}{R} = \frac{f}{16}, \text{ where } R = \frac{DV\rho}{\mu}$$

Under fully developed turbulent motion, the Newtonian methods may be used for a Bingham plastic with the substitution of the coefficient of rigidity for the Newtonian viscosity in the Reynolds number. One remaining difficulty is in connection with the transition zone. There is conclusive evidence that the transition from laminar to turbulent motion depends not only on the modified Reynolds number R_m, but also on diameter, yield value,

(*Concluded on page 97*)

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Electric Automobiles

By R. A. WOLF

From *The Cornell Engineer*, U.S.A.,
Vol. 25, No. 6, March 1960,
pp. 25–26, 2 illustrations.

ALTHOUGH the popularity of electric automobiles in the early 1900's largely disappeared before World War I, they are now an object of renewed interest on the part of the American automobile industry, due to the economy, flexibility, and quiet operation afforded by electric power, and, for the first time in nearly forty years, electric cars and lorries are being manufactured in the U.S.A.

The greatest engineering problem involved in the design of an electric automobile has always been that of recharging the storage batteries furnishing current for the motors. Thus, a typical electric car of the early 1900's could travel 75 miles at 20 mph between rechargings of its ton of storage batteries. As, however, the performance and dependability of the petrol engine improved, longer distances and higher speeds became common, and the electric car could not compete. Now, however, the lowered cost of electricity, the increase in the number of two-car families, and the gradual improvement in storage batteries have caused engineers to look again to electricity as a source of power.

As a result, a number of " plug-in " electric automobiles are already available, or will shortly be available, from American manufacturers. In addition, the American Motors Corporation and the Sonotone Corporation are co-operating on a long-range research project aimed at developing a practical petrol-electric car, while the DeSoto Division of the Chrysler Corporation is carrying out advanced research on a new fuel cell for possible use in electric automobiles.

Of the plug-in type of electric cars, the Charles " Townabout " is a small sports coupé carrying 450 lb of storage batteries which can be recharged overnight from any 110-V outlet, with one 3·2-hp electric motor connected to each rear wheel through reduction gears.

Essentially, the " Townabout ", which has been in production for some months, is designed as a " second " car for shopping, etc., so that it would seldom be called upon to exceed its maximum range of 80 miles. Its performance is also adequate for city driving and, owing to the high torque produced by its motors at low speed, is reported to accelerate to its top speed of 58 mph at a rate which is comparable with that of most light British and Continental cars.

The car's best feature is its economical operation, a complete recharging after 80 miles of driving costing only 18 cents (equivalent to about 5 miles for one penny). Its major disadvantage, common to all plug-in electric cars, is, of course, its range limitation. If service stations could function as recharging stations, battery-operated cars could be used for longer trips, as batteries mounted in removable pods could be traded in at stations for sets of freshly charged cells.

With a view to seeking increased efficiency without range limitations, the petrol-electric car proposed by American Motors and Sonotone makes use of a small petrol engine and a generator for recharging the storage batteries of the car. This petrol-electric power plant has several major advantages over the standard automobile petrol engine. Thus, an automobile engine must operate most of the time at only a small fraction of its rated power, while the engine of the petrol-electric car will operate only at full throttle. In this connection, it is well known that the efficiency of an automobile engine generally increases as its throttle opening increases, so that an engine operating at full throttle is always more efficient than one operating with the throttle almost closed.

An automobile engine must be designed to operate reasonably well over a wide range of engine speeds, while the engine on the petrol-electric car needs to function at one speed only. Thus, the intake and exhaust systems, as well as the spark and valve timing, will be adjusted for peak efficiency under one set of operating conditions. The efficiency increases caused by constant-speed, full-throttle operation should far outweight losses in the batteries and motors, and the power plant of the petrol-electric car should be far more efficient than that of the ordinary automobile.

The storage batteries in the petrol-electric car proposed by American Motors and Sonotone will be specially designed nickel-cadmium cells, which should permit very high charging and discharging rates. Thus, although the petrol engine used might be charging the batteries at a constant rate of only 20 hp, the batteries might deliver energy to the motors at several times this rate for short periods of acceleration or hill-climbing.

The special nickel-cadmium storage batteries developed for the car have plates of nickel mesh covered with nickel powder, the positive and negative electrodes being plated with nickel hydroxide and cadmium hydroxide respectively. Although the plates look smooth, they are actually full of tiny holes which offer a huge contact area between electrodes and electrolyte. It is this large contact area which permits the high charge and discharge rates.

The idea of regenerative braking could also be used to increase the efficiency of the petrol-electric car, and is equally applicable to any type of electric car using battery-driven motors. Regenerative braking makes it possible to salvage the energy normally dissipated by the brakes. When a car is driven in heavy traffic or in hilly country, most of the mechanical energy produced by the engine is eventually dissipated by the brakes. For city or mountain driving, the regenerative brake could greatly increase the the efficiency of the car.

The proposed petrol-electric car does not have the range and power limitations of pure electric cars like the " Townabout ". It should allow a fairly large car to use a small engine and still have plenty of power in reserve. The petrol-electric car will probably not equal the economy of " plug-in " cars, but it should easily better any conventional car with a petrol engine.

Because of the limitations imposed by the second law of thermodynamics and the energy losses due to heat conduction and friction, the conventional internal combustion engine cannot possibly achieve an efficiency of more than 35%. For this reason, the DeSoto investigation is based on the use of a completely different source or power, i.e., the electro-chemical fuel cell, with which efficiencies as high as 75% have been obtained in the laboratory. However, considerable development work will undoubtedly be needed before it will be practical for use in automobiles. Storage of the gaseous fuels presents a major problem, as low-pressure, lightweight tanks would have to be prohibitively large to carry a reasonable

amount of fuel. High-pressure tanks would allow much smaller volumes, but would have to be quite heavy to withstand the pressure. Neither gas can be liquefied conveniently.

DeSoto has built a three-eighths scale " idea car " to illustrate the application of the electro-chemical fuel cell to automobile design. The car would be powered by four lightweight traction motors at the wheels, and the storage batteries used to run the motors would be charged by an electro-chemical cell.

Although the fuel cell will probably not find application in cars for some time, petrol-electric cars like that suggested by the American Motors-Sonotone project are somewhat closer to reality. Petrol-electric cars should provide convenient long-range driving with excellent economy, while the " Townabout ", even in its present form, would make a very satisfactory " second " car. In fact, it may well transpire that the electric motor will eventually replace the petrol engine as a prime mover for the world's automobiles.

Some Aspects of Ultrasonic Testing of Crankshafts

By C. PANSERI and M. ROBBA

From *Rivista di Ingegneria*, Italy,
Vol. 10, No. 3, March 1960,
pp. 257–260, 6 illustrations.

ULTRASONIC inspection methods have been successfully applied to a wide variety of castings, forgings, and welded assemblies. However, when changing from simple to more complicated shapes, this non-destructive method requires the use of specially adapted techniques and equipment. It is not an infrequent occurrence, for instance, that a component can be effectively and thoroughly examined ultrasonically in a matter of minutes, whereas some small variations in its dimensions may require special set-ups for the transducers and a much longer period of examination. Moreover, if the component is already built into a machine, costly dismantling may be necessary to make certain surfaces accessible. Sufficient time must always be allowed for a proper examination, no matter how inconvenient any delays may be, so that it is essential that the time required and the inspection techniques used should be based on a careful analysis of the design of the component.

The two examples given below are intended to illustrate these points.

Fractures in Compressor Crankshafts

Figs. 1 and 2 show two steel crankshafts from compressors, the first of which failed in fatigue at the level of one of the webs, while the second was removed from service after finding deep cracks at the roots of the crankpins, the positions being indicated by heavier lines in Figs. 1 and 2.

These crankshafts had previously been subjected to ultrasonic inspection by the manufacturers. During the manufacturing process, about 70 crankshafts of different sizes and shapes had been inspected in this way but, in order to avoid stoppages of machines, the crankshafts in this instance were inspected without uncovering the cylindrical surfaces (crankpins and journals), by applying the transducers to the end-faces of the crankpins, webs, and journals, as shown in Fig. 1.

Under these experimental conditions and with the types of transducers available, it was possible, in principle, to explore the entire region of most parts of the crankshafts; however, for one group, which included the two crankshafts under consideration, only a partial examination was performed, since some surfaces were not accessible to the ultrasonic pulses, and it was considered at the time that, since all the parts examined seemed free from damage and defects, they could be approved for service.

After a short period of operation, however, the fractures mentioned occurred and, in view of their extent and depth, it can be definitely asserted that the defects were already present when the crankshafts underwent inspection at the factory. At the materials laboratory which was then consulted, the entire problem was therefore reconsidered, and the parts were subjected to further accurate ultrasonic examinations with a view to determining the circumstances that had enabled the defects to remain undetected in the first inspection.

In the case of the crankshaft shown in Fig. 2, the finding was simple, i.e., that all the fractures were situated in an inaccessible region during factory inspection. To identify the defects, it was necessary to use special miniature-type transducers radiating at an angle of 35 deg.,

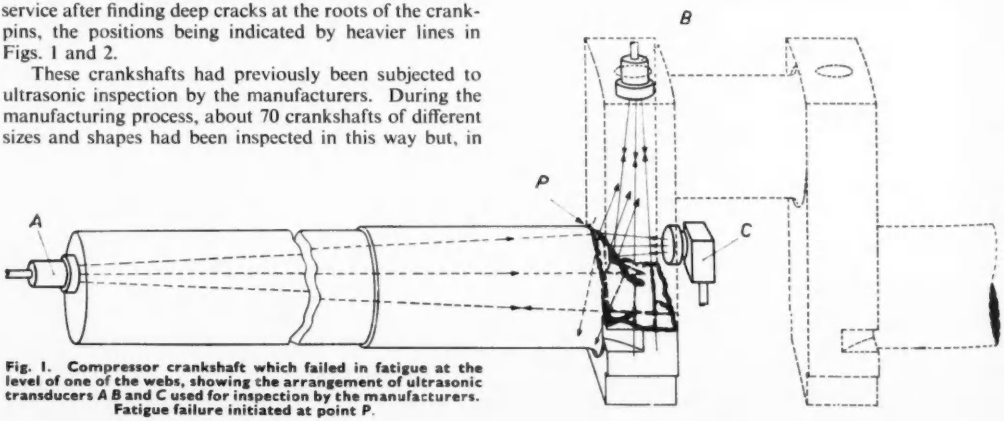


Fig. 1. Compressor crankshaft which failed in fatigue at the level of one of the webs, showing the arrangement of ultrasonic transducers *A B* and *C* used for inspection by the manufacturers. Fatigue failure initiated at point *P*.

which, owing to their small size, could be located in the comparatively restricted space (65 mm) between the web faces of this multi-throw crankshaft. The 35-deg. setting, moreover, made it possible to bring the ultrasonic beams into the regions of the defects, as shown in Fig. 2.

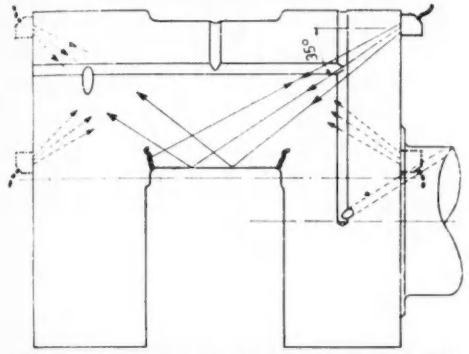


Fig. 2. Part of a compressor crankshaft with deep cracks at the roots of the crankpins, showing arrangement of transducers used for locating the defects.

For the crankshaft in Fig. 1, the considerations were somewhat different. In Fig. 3 it is shown that the fracture branched out into two parts, one of these being the result of fatigue and therefore very likely present as an initial crack during the first inspection, whereas the other was an area of brittle fracture, as was later verified.

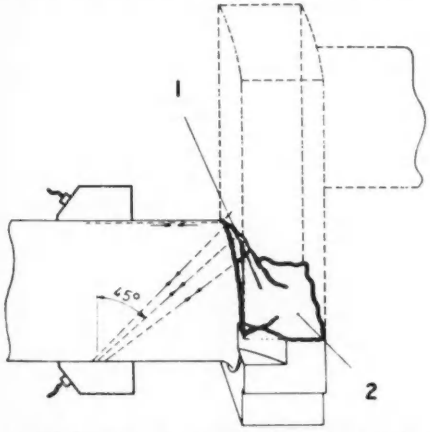


Fig. 3. Suitable arrangement of transducers for detecting the defective area of the crankshaft shown in Fig. 1, showing the region of fatigue failure (1) and the region of brittle fracture (2).

By applying direct-radiating transducers to the positions *A*, *B*, and *C* in Fig. 1, as in the routine inspection, the fatigue region (i.e., the upper branch) could not be identified, since its inclination relative to the three directions of the beam was such that it would not produce any reflections towards the transducers (which, as is known, operate both as transmitters and receivers). The only reflections obtainable were those of the brittle fracture, which was certainly not present during the factory inspection.

To detect the portion of the fracture due to fatigue, it would have been necessary to use transducer heads with a 45-deg. angle, and others set in such a way that the beams passed close to the surface of the journal. The arrangement that could have identified the defective area is shown in Fig. 3.

Metallurgical Investigation of a Steel Crankshaft

Photomicrographs of parts of a crankshaft that had quickly failed in service as a result of fatigue showed a coarse-grained structure and extensive inclusions, whereas a much finer structure with a correspondingly higher fatigue strength could have been obtained by adequate heat treatment (normalizing at 880°C). This example is mentioned in order to draw attention to the interesting possibilities of the ultrasonic method of non-destructive investigations into the grain size and homogeneity of steels. The structure in this case is explored by measuring the attenuation of the ultrasonic beam, instead of its reflections. Again, special equipment is required for this work.

The Interpretation of Rheological Data for Engineering Use

(Concluded from page 94)

velocity, and coefficient of rigidity. Moreover, the transition range is known to be very wide. The best present guide seems to be the observation that strict laminar flow extends only to a friction factor of about 0·008.

In the case of pseudo-plastics the situation is less clear. One procedure, satisfactory at reasonably high rates of shear is to treat the pseudo-plastic as an equivalent Bingham plastic, employing apparent values of the yield value and the coefficient of rigidity. Another procedure, proposed by Metzner[7] involves the use of the conventional (Newtonian) friction-factor/Reynolds-number correlation with a modified Reynolds number defined as

$$\frac{D^{n'}V^{2-n'}\rho}{\gamma}$$

where n' is a flow-behaviour index approximated by the slope on logarithmic co-ordinates of the (dF/dA) to (dV/dX) realtionship, and $\gamma = g_c K' 8^{n'-1}$. In this equation

$$K' = \frac{K(3n' + 1)^{n'}}{4n'} \quad \text{and} \quad K = \frac{(dF/dA)}{(dV/dX)}$$

There is a temptation to simplify the problem by trying to use a single apparent viscosity and to treat the fluid as though it were a Newtonian. This is sometimes satisfactory, but it is also dangerous. The difficulty centres in the choice of the apparent viscosity and of the shear rate at which it should be taken. In turbulent motion, the effective rate of shear is high, and an apparent viscosity taken at 1000 or more reciprocal seconds appears appropriate. Such a value, however, is little different from the coefficient of rigidity or the apparent coefficient of rigidity, so that the procedure reduces to that described above. In laminar motion, the rates of shear are much less and vary more over the flow section. In this case, the use of an apparent viscosity is definitely not recommended, and the Buckingham equation, or some modification of it, is to be preferred.

Generally speaking, the use of an apparent viscosity should be restricted to cases of reasonably constant rate of shear, and the apparent viscosity should be evaluated at the rate of shear of interest.

The Effect of Preheated Welding Wires on Welding Characteristics

By W. T. DeLong, J. H. Bradbury, and H. F. Reid

From *Welding Journal*, U.S.A., Vol. 39, No. 4, April 1960, pp. 328–333, 11 illustrations.

Increased automation in welding places an ever-increasing emphasis on the control of the variables influencing welding characteristics. Traditionally, the variables of prime concern have been welding current, arc voltage, wire size, and rate of travel. Until relatively recently, the length of wire exposed between the contact and the arc has often been overlooked in procedure recommendations. In recent years, however, a number of articles have appeared, stressing the importance of preheating filler metal, and this report summarizes work designed to explore other practical applications of these previously determined theoretical findings.

In this investigation, welds were made in the flat position on lengths of appropriate base metal, using a wide variety of electrical conditions and wire extensions from about 1 to 6 in., wire extension being defined as the length of wire extending beyond the last point of electrical contact. A commercial constant-potential d.c. welding machine was used as the power source. Filler wire was supplied to the arc at a constant rate of feed, using combinations of semi-automatic and fully automatic wire-feeding units and welding heads commercially available.

Most of the investigation was concerned with the effects of preheated solid mild-steel wires on welds made on hot-rolled steel plate, using CO_2-gas-shielded and submerged-arc welding techniques. In addition, exploratory tests were made on stainless-steel and aluminium base materials using the inert-gas-shielded consumable-electrode process. Preliminary work on the open-arc hard surfacing of mild steel completed the study. Tests were designed to explore the limits of potential advantage resulting from the use of preheated wires. Welding conditions, therefore, were not restricted to those combinations that produced commercially acceptable weld deposits, although most of the deposits evaluated met normal industrial standards.

An increase in the length of wire extension was accompanied, in some cases, by increased operating difficulties resulting from uncontrolled movement of the small-diameter filler wire and from the inability to maintain an adequate coverage of shielding gas in the area of the arc. These difficulties were overcome by using, where necessary, an insulating tube around the filler wire. This tube provided the necessary directional control for the wire and ensured normal gas protection for the arc at all times. After visual examination, welds were sectioned and etched to determine the depth of penetration below normal plate level and the height of reinforcement.

CO_2 Welding of Mild Steel

A series of welds was made on hot-rolled steel plate of $\frac{1}{2}$-in. thickness, using mild-steel (rimmed) filler wire, $\frac{1}{16}$ in. in diameter, and a CO_2 shielding gas flowing at the rate of 40 cu ft/hr. Special gas nozzles were employed to keep the nozzle orifice 1 in. from the surface of the plate at all times. Tests were made under a variety of welding conditions and at weld-metal deposition rates of from 8 to 20 lb/hr. In all tests, actual welding current was dependent on the combination of machine voltage, deposition rate, and wire extension being studied.

For any given deposition rate and machine setting, welding current decreased sharply as the length of wire extension increased, as shown in Fig. 1, in which it will be seen that, to deposit the same amount of weld metal, the current required for a 5-in. wire extension was only about half that necessary if less than 1 in. of the filler wire was exposed.

At a constant deposition rate and length of wire extension, changes in machine voltage did not materially alter welding currents. Over most of the range investigated, the 10-V shift in machine setting was accompanied by a 10- to 20-A change in welding current. For short wire extensions and high deposition rates, such changes in welding current were more pronounced, as is evidenced by the increased width of the first portion of the scatter band for the 20-lb/hr data in Fig. 1.

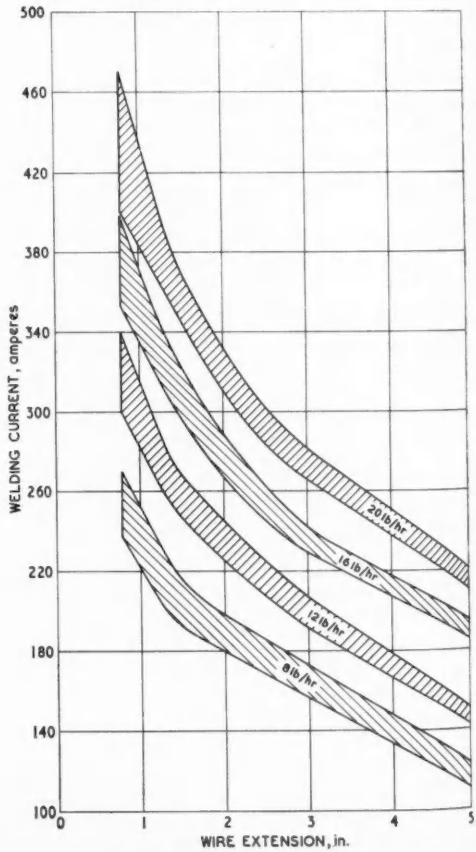


Fig. 1. Effect of wire extension on welding current, in the case of CO_2 welding of mild steel.

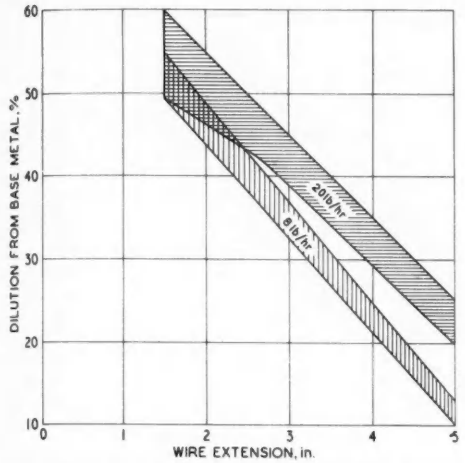


Fig. 2. Effect of wire extension on base-metal dilution, in the case of CO_2 welding of mild steel.

The amount of dilution from the base metal, i.e., the ratio of the area below plate level to the total cross-sectional area, increased somewhat with an increase in deposition rate. At all constant deposition rates, however, dilution decreased sharply with an increase in wire extension. Fig. 2 summarizes the results of tests made at 30-, 35-, and 40-V machine settings and at deposition rates of 8 and 20 lb/hr. In the case of weld metal deposited at a rate of 8 lb/hr, penetration or dilution was reduced nearly 80% by increasing the length of the wire extension to 5 in. Variations in machine voltage altered the dilution from 2½ to 10%, as shown by the width of the cross-hatched areas in Fig. 2.

Submerged-Arc Welding of Mild Steel

A series of submerged-arc welds was made on hot-rolled steel plate of ½ in. thickness, using a mild-steel filler wire of $\frac{5}{32}$-in. diameter and a conventional granular flux. Welds were made under a variety of voltage settings, with the rate of deposition held constant at 16½ and 23 lb/hr.

At both deposition rates, welding current decreased progressively as the length of the wire extension increased, but the decrease was not as sharp as that in the case of welds

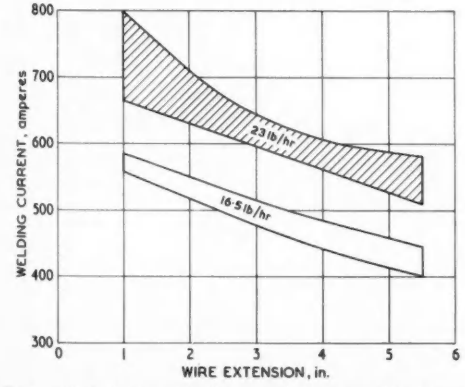


Fig. 3. Effect of wire extension on welding current, in the case of submerged-arc welding of mild steel.

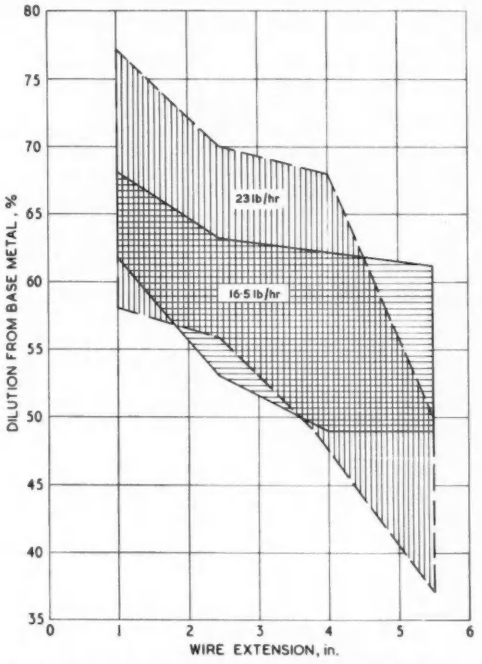


Fig. 4. Effect of wire extension on base-metal dilution, in the case of submerged-arc welding of mild steel.

made under similar conditions, using CO_2-gas-shielded welding techniques. Extending the filler wire to 5½ in. reduced current requirements by from 15 to 20%, without reducing the rate of deposition of the weld metal, as shown in Fig. 3. Changes in machine voltage produced a greater change in welding current under these conditions of testing than that observed in CO_2 welding.

The influence of wire extension on penetration or base-metal dilution was not as pronounced in submerged-arc welding as in CO_2 welding. Generally speaking, dilution, summarized in Fig. 4, decreased with increasing wire extension. For any specific wire extension, however, both sets of data showed a wider scatter of values with changes in machine voltage than that observed in any other tests in this investigation. The cause of these variations was not determined.

Inert-Gas-Shielded Welding of Stainless Steel and Aluminium

The data obtained in the case of CO_2 welding and submerged-arc welding of mild steel showed that changes in the amount of wire extension affected the performance of the filler wires used. Although the amount of variation produced by changes in wire extension appeared to be a function of the particular welding process, in both cases the welding current and the depth of penetration showed distinct changes. Exploratory tests were therefore made, using inert-gas welding techniques on stainless steel and aluminium to determine if these observed trends for mild-steel welding would be valid for other welding processes and base metals.

A series of inert-gas-shielded welds was made on $\frac{3}{8}$-in. Type-304 stainless-steel plate, using $\frac{1}{16}$-in. Type-308 wire as the consumable electrode and argon flowing at a

rate of 40 cfh as the shielding gas. Wire extension was increased progressively from 1½ to 5 in., while machine voltage and deposition rate were held constant at 26 V and 7½ lb/hr respectively. As in other tests in this investigation, special nozzles were used to ensure adequate gas coverage, irrespective of the length of wire extension.

The welding current required to maintain the desired rate of deposition decreased sharply as the extension increased to 5 in., as shown in Fig. 5. Under these conditions, a current of only 110 A was required to secure the same deposition that initially required 180 A.

Penetration or dilution also decreased sharply as the length of the wire extension increased. By balancing wire extension and welding current, virtually nil penetration was achieved. Lack of measurable penetration was not accompanied by lack of fusion. The weld metal appeared to be bonded firmly to the base material in much the same manner as a high-quality brazed joint.

In the case of the exploratory welds on aluminium, ½-in. Type-6061-T6 aluminium plate was used, with $\frac{1}{16}$-in. Type-43S aluminium filler metal and 70 cfh of argon as the shielding gas. Machine voltage was maintained at 26 V and the deposition rate at 4·3 lb/hr.

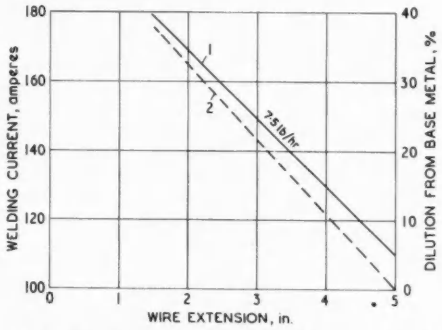


Fig. 5. Effect of wire extension on (1) welding current, and (2) base-metal dilution, in the case of inert-gas-shielded welding of stainless steel.

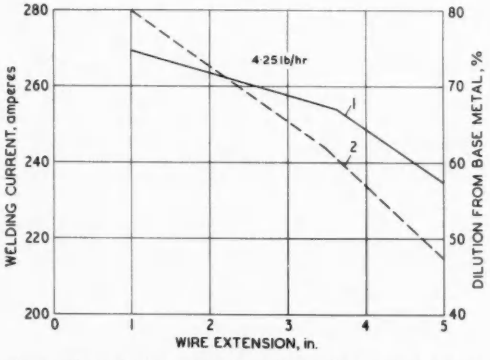


Fig. 6. Effect of wire extension on (1) welding current, and (2) base-metal dilution, in the case of inert-gas-shielded welding of aluminium.

The results of these tests are summarized in Fig. 6, from which it will be seen that both welding current and dilution from the base metal decreased with an increase in wire extension, welding current decreasing by about 20% and dilution by about one-third over the range of wire extensions investigated.

Open-Arc Semi-Automatic Surfacing

Early in the development of tubular alloy-filled wires for open-arc surfacing, it became apparent that the performance of such tubular wires was influenced sharply by the position of the end of the wire with respect to the nozzle. Figure 7 summarizes typical results of a series of tests made on hot-rolled mild-steel plate using $\frac{3}{32}$-in. tubular wires.

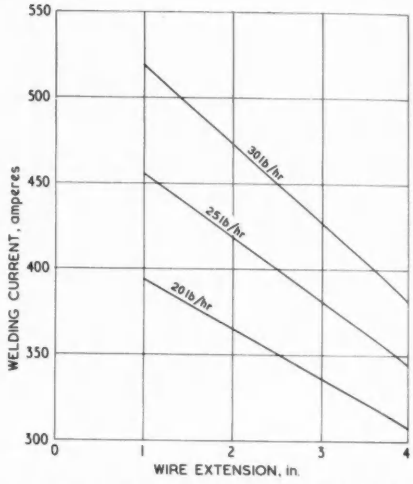


Fig. 7. Effect of wire extension on welding current, in the case of open-arc semi-automatic surfacing of mild-steel plate.

In all tests where deposition rate was held constant, current requirements decreased with increasing wire extension. The amount of the decrease varied with the deposition rate, but generally was of the order of a 20 to 30% reduction as the length of the wire was extended from 1 to 4 in. beyond the holder.

Discussion of Results

The results showed that, irrespective of the base material or type of welding process employed, increased wire extension was accompanied by a decrease in welding current and base-metal penetration. Although the amount of these decreases varied with the base metal and the welding process, the rate of decrease frequently approached a straight-line function for wire extensions of 1 to 5½ in. For shorter extensions, the rate of change was more rapid, resembling an exponential curve. This latter type of curve was most pronounced in data for the CO_2 welding of mild steel.

There are numerous practical applications and advantages to be gained from the use of this principle of controlled preheating of filler wire, and these can be summarized as follows:—

(1) *Decreased Welding Current:* For any specific combination of deposition rate, base material, welding process, and machine voltage, the current required to melt the desired amount of filler metal decreases as the length of wire extension increases. This permits the use of limited-capacity power sources to achieve deposition rates previously considered unattainable or to be used in situations previously considered impractical.

(2) *Increased Deposition Rate:* If welding current rather than deposition rate is held constant, then deposi-

(Concluded on page 129)

Automatic Seven-Station Transfer-Type Crankpin Grinding Machine

BELIEVED to be the largest of its kind ever built, a new machine, known as the Norton No. 2 unitized transfer-type automatic crankpin grinding machine, has been developed by the Norton Company, of Worcester, Massachusetts.

The machine (Fig. 1), which is 90 ft in length and 19 ft in width, has been designed to finish-grind the pins on up to sixty automotive-type crankshafts per hour under completely automatic operating conditions, and essentially consists of seven grinding stations connected by a transfer system. All grinding, loading, unloading, size-control, gauging, and wheel-truing operations are effected automatically, all that is required of the operator being to make adjustments and to take the necessary corrective steps should faults develop, as indicated by lights on a control panel.

Crankshafts are brought to the grinding machine on a conveyor, and an overhead carriage, mounted at right-angles to the conveyor, transfers them to the grinding position. While grinding is in progress, the overhead carriage returns the ground crankshaft to a position over the conveyor, picks up another unground crankshaft, deposits the ground shaft on the conveyor, and transfers the unground shaft to a waiting position over the grinding station, ready to be lowered at the next cycle.

The total time that the grinding wheel is not in contact with the work during the 1-min. cycle is 17 sec, when the truing process takes place, either during one cycle or after a predetermined number of cycles. Automatic truing devices true the face of the wheel and form the correct fillet radii on the corners.

Because the crankpin is not on the centre-line of the crankshaft, proper angular location in offset counter-weighted work-holder blocks is essential to place the desired pin axis exactly on the axis of work rotation. In this machine, the work is accurately located to within 0·002 in. of the exact position, angular location being accomplished in two steps. In the first step, the crankshaft is roughly oriented when it is placed on the conveyor, where it is supported by one main bearing and one pin, the weight of the crankshaft turning the correct side up. A pick-up hook is designed to maintain the relative position and, when the crankshaft is placed in the end blocks, the end pin comes to rest in a Vee on a fixturing template which provides the final accurate angular location.

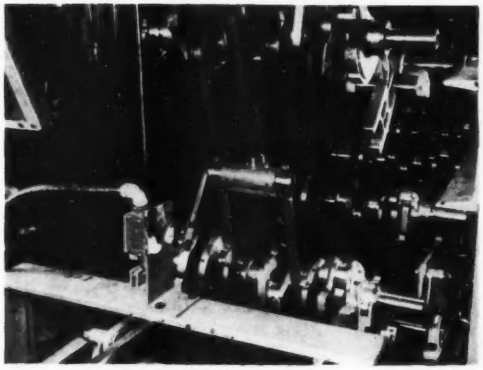


Fig. 2. Hydraulically controlled gauging station.

Axial location must also be precise. Once the crankshaft is angularly located, an axial locator comes into play. As an oval-shaped cam rotates between the cheeks of the crankshaft, it aligns the shaft axially, so that the wheel grinds an equal amount on each cheek. After alignment, the locator retracts, the crankshaft is clamped, and the grinding cycle begins. At the end of the grinding cycle, the headstock drive is so controlled that the work-holding blocks are brought to a correct stopped position to discharge and receive the crankshafts.

The machine is designed to mount 42-in. grinding wheels, and the wheel-spindle is supported at each end for greater rigidity. The grinding cycle consists of a rapid infeed, a rapid feed for shoulder grinding, a slower feed for roughing, followed by a 4-sec dwell, and a very slow infeed for final sizing and finishing of the pin. Infeed is controlled by hydraulic valves.

Correct size is controlled by in-process gauging. When the final size is reached, air gauges actuate the controls which retract the wheel slide, thus ending the grinding cycle. Wheel-wear and diamond-wear compensation are included in the design to ensure correct sizing. Fig. 2 shows a ground shaft deposited at the gauging station, with the gauging head (upper right) swinging down to check the pin bearing for size and straightness.

Post-process gauging (Fig. 3) is effected on the ground crankpin when it returns to the conveyor, three readings on each pin being taken simultaneously to check against taper, as as well exceeded tolerance. If the part should

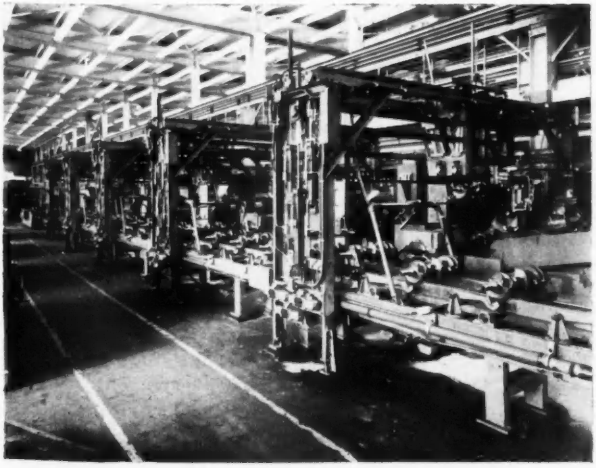


Fig. 1. Side view of the automatic seven-station crankpin grinding machine.

exceed tolerance, the particular grinding station concerned is automatically stopped and the operator is warned by means of signal lights. The rest of the machine can continue to operate by bypassing the station causing trouble.

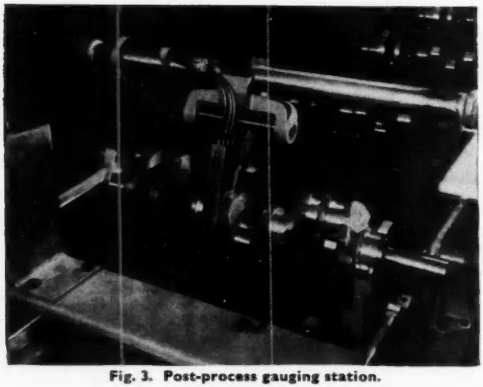


Fig. 3. Post-process gauging station.

Each station has independent controls for use in setting up and making adjustments. One switch changes the station from independent operation to automatic operation from a central master-control station (Fig. 4).

The seventh station, which is actually an extra station, is a standard semi-automatic crankpin grinder which can be adapted to single-pin grinding and is equipped with a transfer mechanism. It is intended for use as a substitute for any of the other stations which may be shut down for wheel-changing, adjustment, or maintenance. A set of simple controls at the pick-up station on the conveyor is set by the operator to enable the seventh station to substitute for any other station. If additional capacity is needed, this station can be operated as a conventional crank-pin grinder with its own operator.

A special double-hook work-loading mechanism speeds the loading of unground crankshafts into and the removal of ground shafts from the work-holders, thus reducing non-productive time between grinds. As the ground crankshaft is removed by one set of hooks, the unground shaft is immediately placed by the second set of hooks into the work-holders, the double-hook work-loading mechanism carrying the previously ground shaft to the transfer mechanism and returning with an unground shaft ready for loading. Fig. 5 shows a ground crankshaft about to be picked up by a pair of hooks, while a second shaft is about to be located.

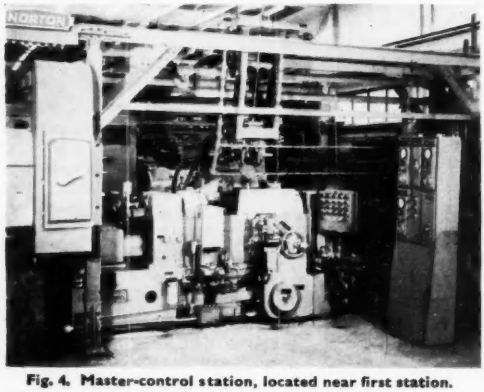


Fig. 4. Master-control station, located near first station.

Crankshafts are moved from station to station by a simple sliding-beam arrangement with Vee-blocks for holding the shafts. When the unground shafts have been picked up and the ground shafts deposited in the Vee-blocks at the loading station, the sliding beam moves forward, carrying the shafts towards the next station. Bellcrank lifting mechanisms then lift the shafts while the sliding beam retracts preparatory to the next pick-up. The sliding beam carries extra crankshafts, as desired, between stations although, with the transferring and automatic bypassing arrangement on the machine, no banking of shafts between operations is needed.

The crankshafts are properly oriented angularly at the start of progress through the grinder, and this same angular position is maintained as the shafts move through all stations. Shafts assume a precise angular location when deposited into the work-holders, and there is no delay for shaft roll-over to obtain precise pin positioning. Work-holders have been so designed that the crankshafts are automatically located in their proper position. In this way, the separate action normally required to place the crankpin into the correct angular position at each station has been eliminated.

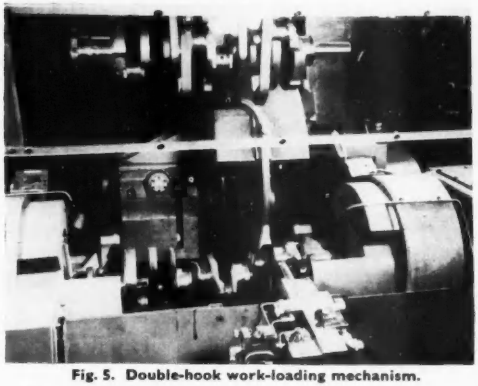


Fig. 5. Double-hook work-loading mechanism.

Longitudinal location of the crankshaft is performed by an aligning mechanism. After the shaft is deposited in the work-holders, this locating mechanism engages the side walls of the pin to be ground and positions the shaft in an axial direction, aligning the pin with the grinding wheel, so that the same amount of stock is removed from each side wall. This alignment mechanism is interlocked with the loading mechanism, work clamping, and wheel feed to ensure the proper sequence of functioning.

An automatically operating wheel-wear compensating device, furnished at each station, is tied in with the operation of the automatic wheel-truing device and moves the wheel-head forward after each truing operation to compensate for reduction in wheel diameter. In addition, each station is provided with an arrangement which ensures a constant peripheral speed of the grinding wheel, thus maintaining the initial efficient cutting speed of the wheel while its size becomes reduced.

For truing the sides of the grinding wheels, a fork-type double-diamond side-truing device is provided. The truing feed of the wheel-head is a separate selective feed and is used only once during the life of the wheel, since the new wheel is trued to the desired width and to the full usable depth.

Developments and Trends in Plant Instrumentation

By L. WALTER, A.M.I.Mech.E., M.S.I.T., M.I.Plant E.

PLANT instrumentation is one of the most important means of providing more goods of better quality and at lower cost. Process instrumentation, whether used for supervision or for fully automatic process control, has therefore made astonishing progress in the U.K. and abroad during the last three decades. New techniques and new devices have become available to improve the application of instruments, and in many branches of industry remote supervision and control have become essential. When assessing trends in plant instrumentation, two main developments come to mind immediately, i.e., the wider use of instruments to increase safety in the plant, and the desire for fully automatic process control.

Improved Safety Equipment

Automatic devices for producing warning signals in case of abnormal conditions, followed in many instances by automatic shut-down of equipment if the deviation of a process parameter from the desired value is dangerous have become numerous. The oldest alarm and shut-down devices use contacts, and many indicating dial instruments are fitted with maximum or minimum contacts. Either the instrument pointer, or a built-in tilting mercury switch makes contact, once a preset value has been reached, and a solenoid or motorized valve closed or opened, as required.

The number of electrical accessories which trigger off current has become quite large. For example, flow switches, or switches for temperature, pressure, vacuum, etc., are in use in thousands of processes, and flame- and explosion-proof types are also available. Micro-switches have also found wide use for limiting movement. The latest development, however, is the proximity switch, in which no contact between the sensing element and the moving component is necessary to produce switching action. A change in capacitance, for example, can provide the signal when the moving part reaches the vicinity of the sensing-switch element, without actually touching it. This category includes devices used for level control, where no contact is permissible, a light beam and photocell for liquids, or the use of an isotope allowing control action to take place.

A fairly recent development is what is called " static switching ", in which electric current can be switched without the use of contacts. Although micro-switches have been greatly improved and their contacts have a considerable life, the demand for contactless switching has been met by electronic switching devices which use no moving contacts at all. Another improvement in automatic tripping for alarm contacts is the use of an amplifier, since the contacts of the necessary auxiliary relay can be lighter.

The latest trend in the incorporation of alarm equipment into instrument panels is the use of visual alarms or annunciators. Audible alarms, such as bells, buzzers, and the like have been used for many years and are still popular. Their drawback is, however, that their use is limited to a small number. For example, two or three buzzers can be applied with different sound characteristics, but, if the number of possible and probable signals increases, another method must be found to draw attention to a critical point of measurement. One such method for identifying the point of alarm is the annunciator panel, which is now available in many forms. A typical annunciator panel comprises visible and audible means of capturing attention, such as combinations of signal lights, or the use of glass panels with warning text, which becomes illuminated in case of danger. A typical example is illustrated in Fig. 1.

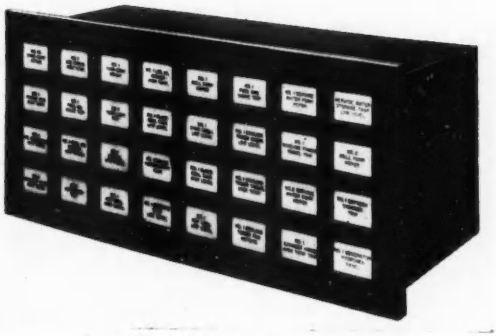


Fig. 1. The " Panalarm " annunciator panel.
Courtesy of Panellit Ltd.)

High-speed automatic alarm logging is widely used in the oil-refining and petrochemical industry, but has also applications in instrumentation for chemical processes. The basic principle of data logging in automatic process control is the automatic detection of deviations of controlled values and their presentation on a log sheet.

The main purpose of a modern data-logging system as part of an automatic control system is, firstly, to check continuously that a number of controlled process variables keep within the desired limits by scanning the plant equipment continuously in a desired sequence, the results usually being printed by a special typewriter on a continuous record chart (Fig. 2). The second function is to give a timely warning if something in the plant goes wrong, and to locate the measuring point or points in the plant where the fault has developed. Several prominent instrument makers in England supply automatic scanning and data-logging systems, ranging from simple multi-point recorder-controllers with alarm contacts fitted to elaborate automatic temperature-scanning and logging systems dealing with one hundred or more measuring points.

Automatic Process Control

The number of branches of industry using fully automatic process control is expanding rapidly. To-day, plant equipment and instrumentation are designed together, in order to provide the most efficient processing conditions; in fact, the selection and arrangement of a control system is one of the basic factors to be considered by the plant designer.

An example of a new electronic fully automatic control system is the multi-component blending equipment developed by the Automatic Control Division of Constructors John Brown Ltd., of London. This equipment, designated the " Autoblender ", is claimed to provide a

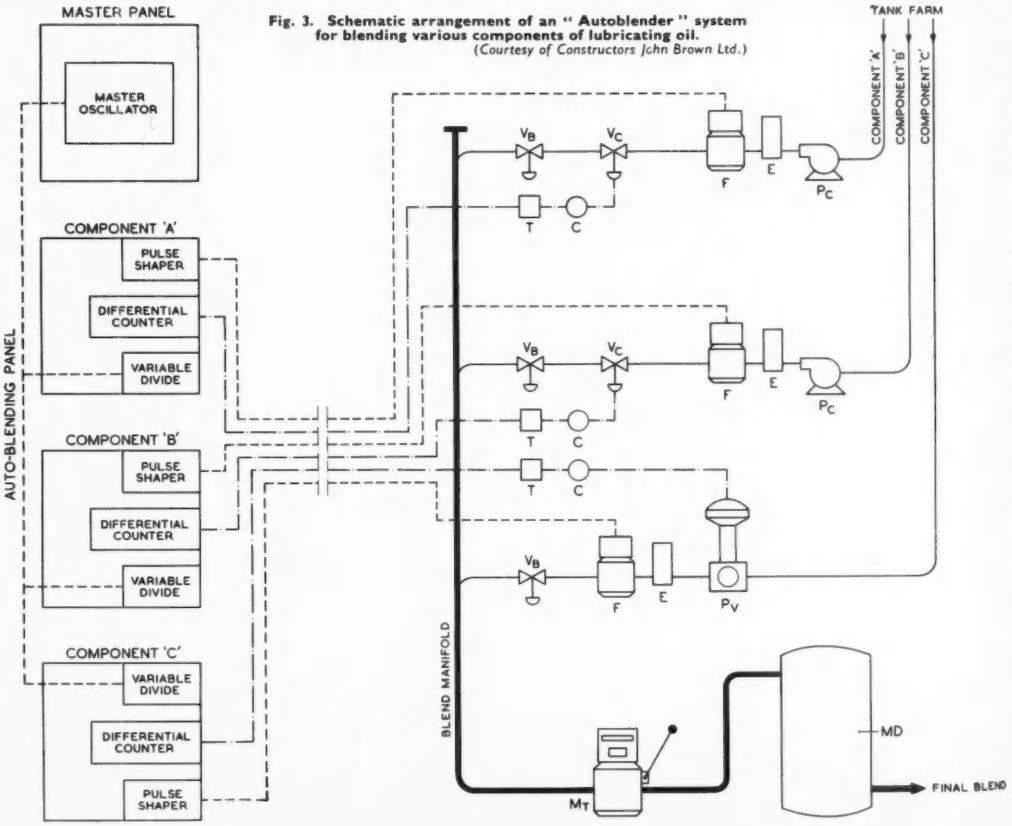
Fig. 2. The " Sunvic " automatic data-logging system.
(Courtesy of Sunvic Controls Ltd.)

blending control system which achieves great accuracy by using digital techniques, and is suitable for the automatic blending of all types of liquids. The following description, however, refers to the blending of lubricating oil.

The basic components are (a) a control panel in desk form, containing a master control unit and a control unit for each component to be blended, with associated electrical and pneumatic control equipment, and (b) auxiliary equipment, as shown in Fig. 3, such as pumps, meters, control valves V_C and block valves V_B, a final mixing unit or dehydrator MD, and the necessary pipework. The control panel can be located within half a mile of the auxiliary equipment. The rate of blending of the various liquid components is automatically regulated by setting the master control unit. None of the control units contains any moving parts, but employs a transistorized electronic circuit which is split up into a number of printed-circuit plug-in cards, with built-in checking facilities.

In operation, a positive-displacement flowmeter F and a centrifugal supply pump P_C or a positive-displacement variable-delivery pump P_V, in conjunction with an air eliminator E, is used for each liquid component. Each flowmeter F is equipped with a special pulse generator, so as to convert the rate of flow to a corresponding pulse train, which is fed to the component control unit. The master control unit contains an electric master oscillator, which continuously generates a pulse train at a rate that can be varied according to operational conditions. These pulses are fed to all the control units for the liquids used in the blend and, in each control unit associated with a blend, the pulse train is divided by a manually preset factor.

Fig. 3. Schematic arrangement of an " Autoblender " system for blending various components of lubricating oil.
(Courtesy of Constructors John Brown Ltd.)



There will obviously be a difference in the number of pulses from the blend-component control units and the pulse generator on the respective flowmeters F, and this difference is accumulated in a differential counter and is then converted into an electrical analogue which produces the desired control signal for the flow-control valve V_C. The latter, however, is of the pneumatically actuated type, so that an electro-pneumatic transducer T is used to provide the necessary variations in air pressure for operating the pneumatic control valve V_C via a controller C. It is claimed that up to ten blend components can be controlled in this way, with accuracies better than 0·25%.

The master control unit is equipped with indicating lights for " stand-by ", " alarm ", and " blend ". The component control units have a flow-deviation indicator, " low " and " high " limit indicator lights and a totalizer. A tally-meter M_T in the blend manifold records the total blend, and the instrument can be equipped with a register and ticket printer. Any desired blend quantity up to 100,000 gallons can be preset and, after reaching the desired volume, the equipment automatically reverts to " stand-by " conditions. A manifold mixer motor is automatically started when a master switch is turned to the " blend " position.

Process or Control Simulation

A method introduced in recent years for the evaluation of proposed instrumentation is process or control simulation, which does not replace time-honoured pilot-plant evaluation, but is complementary, enabling plant designers and instrument engineers to arrive at the most economical solution and to determine the characteristics essential to a control system to be used.

Various types of plant simulators are available, mainly for nuclear work, but also for boilerhouse control, and for certain chemical processes and the like. Computers are used for this work, e.g., to simulate a large power station to which load control equipment is connected. This provides an enormous advantage for instrument manufacturers, as it enables them to test the design and use of the equipment with a simulated system before shipping. An enormous variety of simulated working conditions can thus be rapidly tested prior to despatch.

Quality-Control Equipment

The continuous automatic control of quality of a manufactured product has become a pressing demand with the wider use of elaborate continuous processing methods. For example, in the chemical and oil industries, flow production has advanced rapidly during the last three decades. Another example is to be found in the metal-working industry, where transfer lines for mass production often must be supervised by continuous automatic gauging in intermittent stages of machining.

Quality control of metallurgical processes uses mass spectrometers and other instruments for instantaneous analysis. Modern automatic titration analysers, infra-red analysers, pH-analysers, and ultraviolet spectroscopes are a few examples of instruments used for rapid quality control. Other instruments include viscometers, refractometers, vapour-phase chromatographs, X-ray spectroscopes, and a range of nuclear instruments using isotopes for thickness measurements of moving sheets during processing. For wood, paper, and cloth, an efficient continuous measurement of surface-moisture content is possible during movement by conductivity methods, while moisture content of material in solid, powder, or granular form can be measured by capacitance methods.

Weight Control

Conventional devices for the measurement of the weight or volume of materials are balances, scales, and weighbridges, but, during the last two decades, continuous scales have come into wide operation, e.g., for conveyors (Fig. 4). Some of these weighing systems produce a desired sequence of batching and automatic proportioning. For example, " ready-mix " concrete plants can now be controlled by push-button methods.

Fig. 4. The " Emiway " continuous electronic weighing system, as fitted to a conventional scale.
(Courtesy of E.M.I. Electronics Ltd.)

Electronic load cells are now available and use no levers or pivots, the sensing element of the load cell being an electromagnetic transducer or a resistance strain gauge. This complete absence of moving parts in load cells reduces maintenance.

Electronic Computers

Up to now, there has been considerable discussion about the use of computers for production lines. A number of computer designs have already become available, but it appears that little is known about installations in actual operation. On the one hand, claims have been made that automatic digital-computer control will be an enormous blessing for continuous processing, while, on the other hand, warnings have been given to industry to be cautious regarding their adoption. The fact is that there may be some truth in the statement that some computer manufacturers have promised too much too soon. It has also been said that the computer is not supposed to replace present-day control systems, but to be complementary to them and only to provide a (sometimes very desirable) refinement.

Some time ago, an enquiry was made by the writer to two of the largest computer manufacturers in England with regard to the possibilities of specifying electronic computer control for a chemical process, and the results of this enquiry were not encouraging, insofar as actual operational experience is concerned. In the author's opinion, the high cost of computing equipment, the need to employ skilled programming mathematicians or specialized engineers, space requirements, maintenance costs, and many more financial and technical considerations seem to make it most unlikely that top management or plant management will lightheartedly undertake the use of computers for automatic process control.

It is true, of course, that the oil industry, which apparently has money to burn, was among the first to order process-control computers in the U.S.A. and, although

their operational experience in this connection was not altogether unsatisfactory, it was certainly by no means outstandingly good. Thus, the computer, which was used as a guide for supervising plant-control engineers, and not for fully automatic process control, went out of action after 24 days, when a component failed. Additional failures followed later, but were corrected by replacing the defective components concerned. In themselves, these failures were by no means serious, but there is no need to indicate to an experienced chemical-plant engineer the disastrous consequences that might have ensued if, instead of merely acting as a guide to the supervising plant operator, the computer-controller had actually been in full charge of processing.

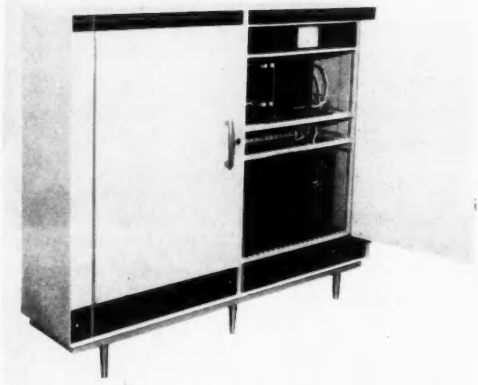


Fig. 5. The Elliott 803 transistorized digital computer.
(Courtesy of Elliott-Automation Ltd.)

Despite the above, it should be noted that a recently published statistical account of sales of British-made electronic computers has revealed an interesting fact about the actual uses of computers for process control in the U.S.A., as it appears that not less than ten Elliott 803 computers will shortly go into practical operation for process-control purposes in American plants. The results may not become known for some time, but there is certainly some good reason why this type of computer has been chosen in the face of extremely keen competition. Possibly, the answer lies in the fact that the Elliott 803 electronic digital computer is a general-purpose machine of great compactness and simplicity, making it eminently suitable for industrial process work. Contained in a single cabinet measuring only 66 × 16 × 56 in., the Elliott 803 computer (Fig. 5) contains a Mullard 4096-word ferrite-core matrix store, an Elliott high-speed punched paper-tape reader being used as the input, with a paper-tape output produced on Creed HS-25 punch equipment. No thermionic valves are used, all logical and storage functions being performed by magnetic cores switched by junction transistors, while solid-state devices convert the a.c. mains voltage to the required d.c. low voltage.

In order to control an entire process unit and to account for interactions of variables, it has been found that the digital computer offers substantial economic advantages over the analogue type. In practice, a number of studies have revealed that a medium-speed transistorized digital computer seems to be suitable for conventional chemical processing.

One of the first chemical plants in the U.S.A. to bring a computer into plant operation is the fully automated vinyl chloride monomer works of the B. F. Goodrich Chemical Co., of Calvert City, Ky, this reputedly being the first in the chemical-processing field in the U.S.A. to utilize in practice a digital system. The chemical process was specifically designed for computer control, and the system actually exercises " closed-loop " control over the whole chemical process. Logging of operating data and of computed values is also performed. The computer accepts instrument signals, computes at high speed, makes logical decisions, and transmits output signals to adjust the set points of numerous control instruments in the plant. According to the users, many process variables are continuously monitored, automatically analysed, and the processing is so adjusted that optimum efficiency is secured. Built-in analogue-digital conversion, transistorized circuits, printed wiring, and a large magnetic-drum memory are notable features.

It is said that a development in linear programming will be the advance preparation of production schedules in manufacturing runs, e.g., in machining for mass production, such as is encountered in the motor-car industry. Taking machine times, the cost of materials and labour, and general overheads into account, a computer will reveal the most economical production programme.

The first time in Britain that a very complex process has been simulated long before the actual plant has even been designed in detail was recently announced by E.M.I. Electronics Ltd. In this case, an E.M.I. analogue computer was used in connection with the new chemical plant of Laporte Chemicals Ltd. at Warrington, where hydrogen peroxide is manufactured. The purpose of the study was to find out whether the capacities of various vessels would be sufficient for all major flow changes, including start-up and shut-down conditions. Another problem solved was the determination of optimum control settings of the numerous automatic plant-control instruments. The determination of points of excessive sensitivity to oscillator disturbances was another investigation problem.

By applying time acceleration in the ratio of 60:1, the adequacy of a simple proportional control mode on seven subsidiary control loops was quickly established. The required stability of control was found to be satisfactory, as also were the pumping capacities.

Likely Trends in Plant Instrumentation

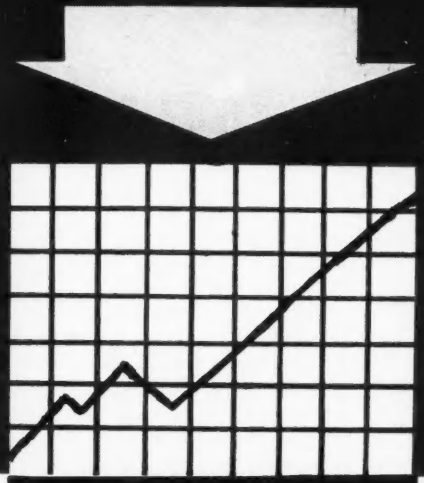
It is impossible to expect exact predictions of future developments in process control and plant process instrumentation, because new manufacturing process methods may easily come along which could radically change the relevant instrumentation. New methods and new materials are being developed rapidly, and batch processing is being more and more superseded by continuous manufacturing methods.

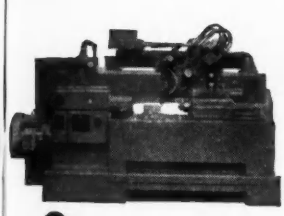
As far as instrument makers are concerned, the trend is already becoming clearer. Simpler mechanisms, easier accessibility and servicing of working parts, standardization of basic components, and, in general, greatly improved instrument designs are now predominant. Miniaturization, the wider use of transistors, and the elimination of moving mechanical parts are trends which can be observed everywhere, and are bound to increase. Modern automatic control instruments have already means for easy adjustment of the various control elements, and further improvements can be expected.

The wider use of micro-wave links for the remote transmission of measured values over very great dis-

(Concluded on page 119)

TO MAKE PRODUCTION MEET DEMAND SEE...





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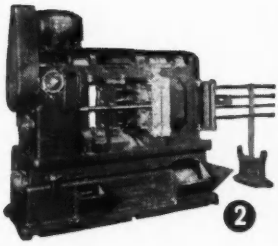

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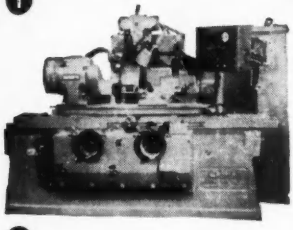

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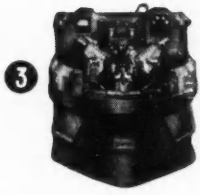

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5

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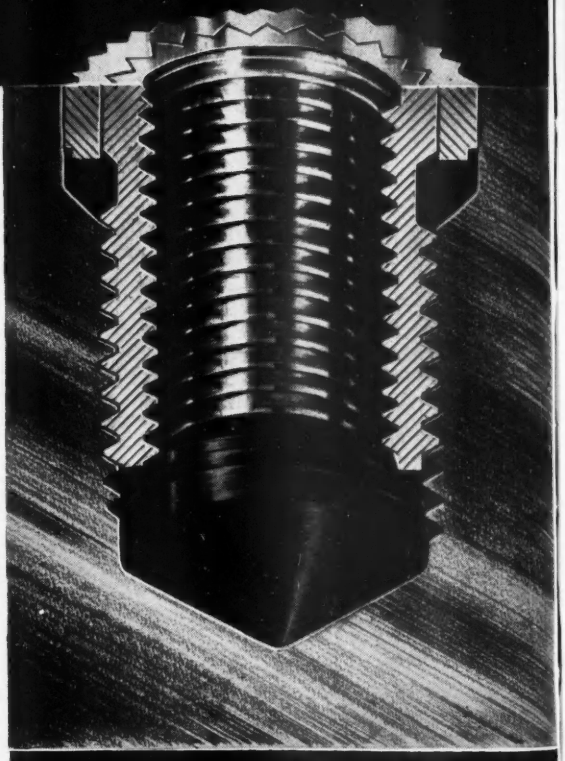

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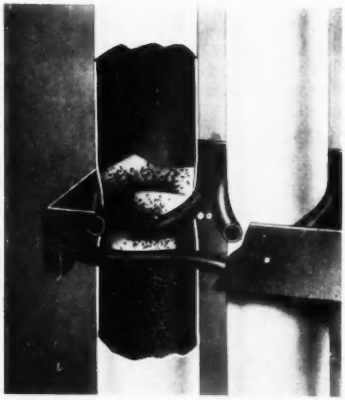
TAS/IS10

British Industrial Developments

Bag Filters for Dust-Collection Plant

A further addition to the range of dust-collection and control plant produced by the Gas Cleaning Division of W. C. Holmes & Co. Ltd., of Turnbridge, Huddersfield, is the Holmes-Retroflux bag filter, which was developed in Germany by Standard Filterbau Gesellschaft m.b.H., of Münster, and is to be manufactured by Holmes in the U.K. under license. This filter has numerous advantages over conventional bag filters and is particularly suitable for those applications where high dust burdens are encountered and/or dusts of an adhesive nature have to be collected. Of advanced design, it incorporates an extremely efficient and continuous method of cleaning the filter bags, ensuring that large volumes can be handled with a constant pressure drop and high collection efficiency. In fact, an efficiency in excess of 99% for all particles, including those of sub-micron size, can be guaranteed.

In operation, dust-laden air enters the header in the casing and is distributed to the inside of the filter bags, the air and dust moving in the same direction. The tendency of the dust to settle by gravity is not impeded by air currents, as the air passes through the filter bags radially and the air velocity gradually diminishes to zero at their lowest end. The dust collected on the inner surface of the filter bags is continuously dislodged by the passage of high-velocity air jets through the fabric in the reverse direction to the main air stream, the dislodged dust falling by gravity to a worm conveyor or hopper below. The use of high-velocity air jets is a design feature of the filter which dispenses with the rapping or shaking mechanism and separate compartments encountered in other types of bag filters.



The jet tubes have a narrow slot in the face, in contact with the filter bag, and are specially shaped and finished to avoid damage to the fabric. The ends of the tubes are set in hollow frames suspended by chains and supplied with high-pressure air from a blower via a flexible hose. The frames operate in counterbalanced pairs when large volumes of air are being filtered, each frame being capable of cleaning the complete length of up to 36 bags. A cutaway view of a section of a hollow frame and the jet tubes around two filter bags is shown in the illustration.

The jet tubes are mounted in pairs, one pair being positioned about 3 in. below and at 90 deg. to the other, so that progressive cleaning of the filter bags can be achieved efficiently and without damage to the fabric. Each jet tube is in contact with the surface of the bag over a quarter of its circumference only, and in operation the bag becomes slightly elliptical in shape as each pair of tubes travels along its length. This arrangement of the jet tubes ensures that the bag is not constrained in any way. Creases do not form in the fabric, and wear is reduced to such an extent that filtering media such as glass-fibre can be used successfully when handling hot flue gases. The reciprocating frames carrying the reverse jet tubes travel at a very slow speed, also reducing wear and tear on the material of the filter bags.

A major advantage is that each filter bag is continuously and efficiently cleaned over its entire surface area. The high-velocity jet of air passing through the fabric is measured in thousands of feet per minute, compared with less than ten feet per minute for the normal filtering air speed through conventional filter bags. One important result of this efficient cleaning is that the filter resistance can be maintained at approximately half of that normally experienced with a conventional bag filter, without sacrificing any drop in efficiency. An appreciable saving in power consumption is therefore achieved.

Handling Plant for Aluminium Swarf

A handling, storage, and sifting plant for the manufacture of exothermic compounds has been supplied to Berk Exothermics Ltd. by Thomas Robinson & Son Ltd., of Rochdale. These compounds are intended for risers used in the foundry industry, and their manufacture in Britain is comparatively new. Aluminium swarf, iron oxide, dextrine, and other chemicals are used in the production of these compounds, which can produce intense heat by chemical reaction, supplying heat to the metal within a riser and thus reducing the amount of metal required; at the same time, they establish a temperature gradient within the casting. The conductivity of the burnt-out residue compares favourably with conventional insulating refractory materials.

The comprehensive plant is for aluminium swarf, which is the primary manufacturing material used. The swarf includes dressings, grindings, and dross from casting producers, as well as powdered refined aluminium, highly efficient sifting being required to produce the mesh size necessary for quality production. The swarf is fed to the plant from outside the building via a hopper equipped with a dust-extraction canopy coupled to the main exhaust system. Conveyance of the swarf from the hopper to a Robinson Rexman screening machine is accomplished at the rate of five tons per hour by a bucket elevator, this being independently driven by an electric motor.

The screening machine has a totally enclosed leak-proof sieve securely clamped in a steel frame, driven from the feed end by a gearless mechanism, which, by means

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of special carrying rods supporting the sieve frame, imparts a rotary action at the feed end and a reciprocating action at the tail end. Rubber-ball cleaners are fitted below the sieve and keep the cover free from obstruction and operating at maximum efficiency. Two separations are effected by this machine, i.e., the material which passes through a wire mesh of 1240 microns aperture, and the overtailed rejects, which fall by gravity spouting to a reject bin of 2 tons capacity for out-loading.

A further elevator is used to convey the material passing through the screening machine to a worm conveyor, mounted above six steel storage bins of 10 tons capacity, where the swarf is deposited in its respective bin, according to its aluminium content. All delivery slides fitted below the worm conveyor used for depositing the swarf into the bins are controlled by chains from the ground floor. The gravity discharge of swarf from the storage bins to the worm conveyor beneath is controlled by adjustable slides fitted to the connecting spouts. Discharge from the bin is effected at the rate of three tons per hour, the conveyor delivering to a further elevator, which feeds a Robinson " Minisifter " mounted on the platform at the end of the line of bins.

The " Minisifter " is a compact machine occupying a floor space of only 4 × 4 ft, but with a sifting area of 54 sq ft, using a stack of six leak-proof sieves, clamped to a base and gyrated in a 2-in. circle at 250 rpm. Three mesh-size products are produced by this machine, i.e., swarf which will not pass through a wire mesh of about 500 microns aperture, swarf which will not pass through a wire mesh of about 260 microns aperture, and the swarf which passes through the 260-micron mesh. These three mesh-size products are allowed to flow by gravity spouting to portable metal containers, each holding 100 lb of swarf. To facilitate easy identification of the mesh size of the swarf, coloured tags are attached to each container as they are filled. The containers are then placed on a pallet and stacked by fork-lift trucks.

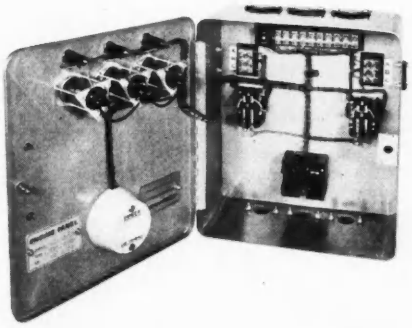
All motors in the plant are flameproofed and are started from control panels in an adjacent building. They cannot be started until a warning horn has been operated for a period of 15 sec. A further delay of 45 sec occurs before the first motor can be operated, and the sequence commences with the " Minisifter " at the delivery end of the plant, ensuring that all machinery is operating before swarf commences to enter the plant.

Diesel-Engine Protection Panels

A complete range of diesel-engine protection panels, for mounting remote from the engine and engine service switches, is being produced by the Special Products Department of A.E.I. Radio and Electronic Components Division, of London, W.C.2, and can be supplied to give immediate visual and audible warning of failure in lubrication and cooling systems and, if required, subsequent shut-down.

The range covers panels having two alarm or two shut-down circuits to types providing either four alarm, four shut-down, or three alarm and three shut-down circuits, with variants between these extremes, including main panels for use in single-engine installations or for the first or main engine in a multi-engine installation and extension units (for all engines except the main engine in a multi-engine installation). In addition, there are panels for indicating overspeed running and for shutting down the engine in such an event, a test circuit for checking the various warning lamps and shut-down indicators, and a cancellation circuit for cutting out the audible warning note while a fault is being remedied. These units are supplied in the combination necessary to customer's requirements.

The alarm or shut-down relays on main and extension



panels are actuated by pressure- or temperature-sensitive switches mounted at appropriate points in the diesel engine and set to operate at the particular pressure or temperature decided on for alarm or shut-down. Shut-down relays lock mechanically, following a fault actuating the shut-down circuits, and must be reset manually. Two extra switches are fitted to shut-down relays, these switches having contacts which are normally open and wired to outgoing terminal blocks. The contacts can be used to complete an audible alarm circuit operating in conjunction with the shut-down relay, or to complete a circuit-breaker shunt trip where engines are running in parallel and reverse current protection is not provided. Overspeed panels operate in conjunction with main panels and incorporate a tachometer indicator and a relay to actuate alarm or shut-down circuits. The panel is fed from a tachometer transmitter mounted on the engine.

Dual-Purpose Multi-Fuel Incinerator

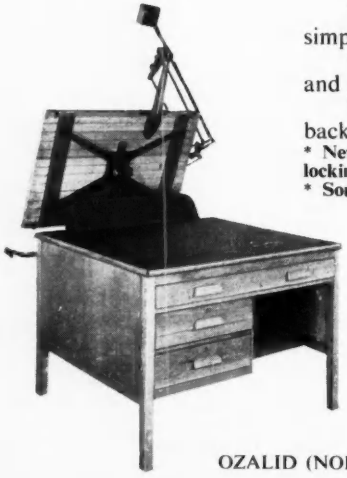
Although the Hoskinson multi-fuel incinerator is an American invention, it is interesting (and gratifying) to note that the licensees for the U.K., Europe, and other overseas territories, the Boston Marine & General Engineering Co. Ltd., of Wolverhampton, a subsidiary of Midland Industries Ltd., have been able to incorporate so many additional features and improvements in efficiency that the American originators are now ordering British-made units at the rate of between 600 and 1000 per year. Essentially, the Hoskinson incinerator is a dual-purpose unit, in that it not only destroys without smoke or smell any type of rubbish, including rubber, plastics, leather, and paint in tins, but is also an efficient space-heating unit which can be used for supplying heat to all types of industrial and commercial premises.

The fundamental principle of the smoke-eliminating equipment is that of supplying smoke issuing from the furnace with the necessary air for combustion and temperature for ignition. To this end, a small oil burner, consuming about 0·5 gph of fuel, is mounted at the base of the chimney, in conjunction with a forced-draught fan. The air from the fan passes through a special diffuser and supports the combustion of oil, mixing with the

A drawing board mounting with

POSITIVE LOCKIN

vertical and angular adjustment



The Horsfall drawing board mounting unit incorporates an entirely simple method of adjusting both the height and angle of the board.

Operation of the raise and fall and the angular adjustments are finger and give positive locking without the use of a friction device.

The Horsfall Unit may be used either free standing or mounted on bench back reference table.

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smoke, which burns continuously within the inner stack. The chimney is designed as a carburettor and consists essentially of two concentric cylinders. Air passes into the annular space and passes upwards, where it enters the chimney. This highly preheated air then mixes with the remainder of the smoke, and complete combustion of the gases is assured. The resulting smoke-destroying action is extremely rapid, so much so that all traces of smoke are eliminated within one second of turning on the equipment.

Space heating is achieved by a high-powered fan blowing air through the heat exchanger. The gases from the furnace pass through the inner space, imparting their heat to the air before passing into the chimney and smoke-eliminating chamber. Cleaning is simple and takes not more than from 3 to 4 min. As normal cast iron would not withstand the operating temperatures, the specification includes a nickel-chrome content in all cast-iron parts, ensuring a long life for the incinerator furnace. The rate of firing is up to 300 lb/hr, and large rubbish is easily admitted through the furnace door, which measures 29 × 15 in.

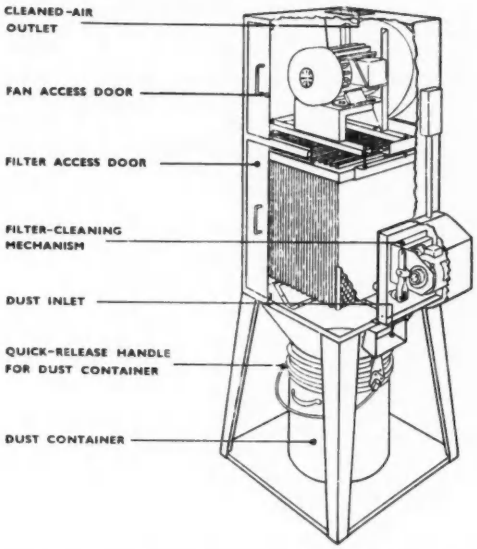
In order to maintain heat when the available rubbish has been consumed, the heater is fitted with an automatic oil burner. The burner is mounted on slide rails at the rear of the furnace and, when pushed into the operating position, automatically changes the electrical circuit to automatic oil-fired space heating. Room thermostats may be fitted, where desired. When rubbish is available, the oil burner is withdrawn on its rails, and the heater changes over to automatic smoke elimination, bringing the chimney burner into operation. Both oil burners have flame-failure protection and automatic ignition, operated from a common control panel. The oil-supply valve operates instantaneously as the burner is withdrawn, transferring the oil supply from the furnace to the chimney burner. The change-over from rubbish to oil takes only a few minutes, while the furnace residue is cleaned out and the oil burner slid into position. This aspect of the unit is extremely important where rubbish supplies are intermittent or when space heating is required to be automatic before personnel are actually on the premises.

Self-Contained Dust-Collector Unit

Completely self-contained, the new " Unimaster " dust collector, announced by Dallow Lambert & Co. Ltd., of Thurmaston, Leicester, has been introduced as the successor to the well-known Dallow Lambert " Dustmaster " and embodies numerous improvements and special features. It can be used for the effective control of almost every type of dust produced by an extremely wide range of machines and processes, and applications requiring a large air volume, but producing little dust, can be dealt with just as efficiently as those in which the air requirement is small and the dust load is heavy, while light bulky dusts can be handled as easily as heavy concentrated dusts.

In the new " Unimaster " collector, the filter element is readily removable for inspection and consists of individual pads or envelopes mounted in a common frame which is carefully and efficiently sealed from the fan chamber. The filter assembly is self-locating and is removed by disconnecting a link connecting the filter mattress to the shaking mechanism, and then releasing four nuts, after which the element is free to slide out of the case. The filter pads or envelopes are available in a variety of materials according to the dust being handled, and enclose special Dallow Lambert inserts of patented design, these inserts forming the heart of the air-cushioned cleaning system, which is an outstanding feature of this dust-collecting unit.

The patented filter-cleaning mechanism is of a completely new motorized design, in which a $\frac{1}{8}$-hp electric motor transmits an oscillating movement, by means of an eccentric, to the inserts in the filter pads or envelopes, these inserts consisting of a flexible rustproof mesh mounted in a rigid frame. The oscillating movement causes the mesh in the frame to move rapidly backwards and forwards and induces an air current in a reverse direction through the filter fabric. This air current, allied with the oscillatory movement of the filter pads or envelopes, quickly, gently, and efficiently removes the accumulated dust on the filter fabric, the filter then being ready for a further period of service. Alternative methods of control are available. Thus, the cleaning mechanism can be operated for as long as a button is kept depressed, or the cleaning operation can be carried out on a preset cycle which automatically comes into effect when the fan-motor stop-button is depressed.



The dust container is available in two sizes, i.e., 2 and 4 cu ft. A taper bin is now used to make the maximum use of the available floor space, this bin being sealed to the unit by a special quick-release mechanism of patented design. By using an over-centre cam operating device, the sealing-gear handle has only to be raised and will remain in the release position without catches or clips of any kind whatsoever, after which the bin can be removed, emptied, and replaced; re-sealing is effected very simply by lowering the handle of the sealing gear.

The new collector is initially available in the 70-series (70 sq ft of filter-cloth area), with a fan-capacity ranging from 0 cfm at 6·2 in. w.g. to 765 cfm at 3·3 in. w.g. However, a complete range of " Unimaster " collectors, with filter-cloth areas up to 250 sq ft, will be available very shortly.

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THE DOUBLE SEALING EMPIRE RUBBER GROMMET

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considerably reduces range of sizes
because the same grommet can be used with
several plate thicknesses or cable sizes

PAT. APP. No. 5255/59

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Any one size will not only accommodate itself to a variety of mounting plate thicknesses, but (designed for cable or control rod) will take these in a variety of sizes and be weather-, water- and dust-proof at a variety of angles to the cable or rod.

Because of its capacity to conform to many varying requirements, it enables a workshop stock range of grommets to be reduced to perhaps one tenth of that at present maintained.

THE NEW BLIND GROMMET

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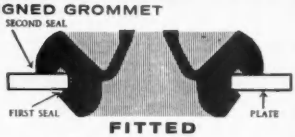
THE NEW DESIGNED GROMMET

FREE



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Note how when sprung into position the grommet provides a perfect double seal by its own permanent pressures. The angled groove also creates a tight pressure hold on the metal plate.

In the cable grommet variety the same double pressure seal is created, allied to tight seal on various diameters of cable. This new grommet gives sound sealing at *all* vital points.

A useful feature of this cable grommet is that by reason of the designed taper of the cable entry and the flexibility of the web, a considerable angle of cable entry and a variety of cable size are possible. This avoids necessity for special grommets with angled bores.

In the conventional grommet, only one thickness of plate and only one size of cable can be accommodated. No effective seal is afforded by the parallel groove.

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ADDITIONAL ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

A Laboratory Evaluation of Zinc Anodes in Sea-Water

By J. A. H. Carson, W. L. M. Phillips, and J. R. Wellington
From *Corrosion*, U.S.A.,
Vol. 16, No. 4, April 1960,
pp. 107–113, 18 illustrations.

The effects of composition on the operating characteristics of zinc galvanic anodes in sea-water have been reported by various investigators, who, in general, have reached the same basic conclusions, i.e., that the presence of iron in zinc anodes is detrimental to performance, and, in an otherwise pure zinc anode, the iron content must be held to a few parts per million. They have also found that the addition of certain alloying elements, notably aluminium or aluminium plus one other metal, results in a more effective anode and permits an increase in the amount of iron which can be tolerated. Thus, these investigators were successful in pinpointing the cause of failure of commercial anodes and were able to suggest or show that the use of certain zinc alloys would result in galvanic anodes with improved characteristics.

While the results of these investigators were in accord on the major factors mentioned above, the effect of more detailed factors was not so clearly defined, and even somewhat conflicting. One of these factors is the effect of current density and time and, in this connection, since the preferred galvanic anode alloy is one that will show little anodic polarization with time over a wide range of anode current densities, it is necessary to take account of current density when comparing alloy performance.

This paper presents data on the anodic polarization of various zinc alloys in natural sea-water, and describes the experimental technique and procedures employed. The combined effects of iron, as an impurity, over the range of 0·0003% to 0·0320%, and aluminium additions over the range 0 to 22%, were investigated at five controlled anode-current densities ranging from 0·5 to 20 mA/sq in., for times up to 100 days. The interrelated effects of iron, aluminium, current density, and time are presented by means of graphs and charts.

The test results confirm the major conclusions of the earlier investigators with respect to the detrimental effect of iron and the beneficial effect of small aluminium additions. The results show that some of the anomalous results of the earlier work may be explained on the basis of the interrelated effects of composition, current density, and time. Within the range of compositions tested, the preferred zinc anode alloy is shown to be one containing 0·3 to 0·6% aluminium, with the iron content controlled in the range between 0·001 and 0·005%.

Arc Welding in a Steam Atmosphere

By L. C. Sapiro
From *Svarochnoye Proizvodstvo*, Russia,
No. 4, April 1960,
pp. 31–32, 1 illustration.

Utilizing steam as the protective atmosphere, a new consumable-electrode arc-welding process developed at the Ukranian Institute of Electrowelding is claimed to achieve high-quality corrosion-resistant welded joints with reduced impurity contents. In tests carried out to investigate the oxidizing effect of the steam and to establish its influence on the silicon, manganese, and other contents of the welds, conventional semi-automatic arc-welding equipment was used, fitted with a flanged sleeve through which steam, supplied via a hose and a nozzle, entered the working zone surrounding the consumable electrode. Welding was effected with standard 2-mm electrodes, using direct current of 220 A and 30 to 35 V.

For the purpose of these tests, it was found more convenient to use the length of the steam jet as a parameter, instead of steam pressure or consumption. In one series of tests, welding was carried out at different lengths of the steam jet, and the effects of varying the length on the composition of the joint were examined. It was found that, in general, the purity of the welded joint tended to increase with increasing steam-jet length. For example, with a jet length of 50 mm, one welded joint contained 0·08% carbon, 0·19% silicon, 0·62% manganese, 0·022% sulphur, and 0·025% phosphorus, whereas, with a jet length of 200 mm, it contained 0·08% carbon, 0·11% silicon, 0·38% manganese, 0·025% sulphur, and 0·017% phosphorus. Apparently, a steam-jet length of 200 mm was the maximum possible in practice, as, beyond this length, it was found that the welded joints deteriorated in quality, owing to spatter.

In additional tests with two types of standard electrodes and a steam-jet length of 80 mm, welded deposits of good corrosion resistance and of superior mechanical properties were obtained, typical values being an ultimate tensile strength of 41 to 45 kg/mm², a yield strength of 27 to 32 kg/mm², an elongation of 22 to 30%, a reduction of area of 34 to 64%, and an impact strength of 11 to 13 kgm/cm². In addition, it was found that the porosity of the joints was reduced to a minimum. Nevertheless, it is pointed out that porosity tends to increase considerably if air is allowed to enter the welding pool, the nitrogen in the air being conducive to the formation of cavities and large pores in the welds. For this reason, it is recommended that, after completion of welding, the steam jet should be left in operation for a further period of from 1 to 2 minutes, to prevent contamination of the weld by air during the process of solidification.

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The Spot-Welding of Carbon Steels

By I. W. JOHNSON
From *Welding Journal*, U.S.A.,
Vol. 39, No. 3, March 1960,
pp. 89s–96s, 8 illustrations.

CARBON steels owe their properties chiefly to the presence of varying percentages of carbon, without substantial additions of other alloying elements. In general, low-carbon or mild steel contains 0·30% or less carbon, medium-carbon steels 0·30% to 0·45% carbon, and high-carbon steel more than 0·45% carbon. The carbon-content dividing point between low- and medium-carbon steels varies in different areas of usage. Where resistance welding and its inherent rapid heating and cooling is involved, 0·20% carbon is usually considered the dividing point.

In this report, which summarizes all available data and information on the spot-welding of carbon steels, it is pointed out that, metallurgically speaking, spot-welding differs from other welding processes primarily because of the greater speed in reaching welding temperature and the very rapid cooling of the weld and adjacent heat-affected zone. Low-carbon steel presents no difficult metallurgical problems, but an increase in carbon content into the medium-carbon range necessitates post-heat treatment.

Tensile-shear strength varies directly with the diameter of the spot weld at the interface, and can be calculated roughly, based on the area at the interface and the strength of the material in the annealed state. The fatigue strength of spot welds is inherently low, this being a mechanical phenomenon and not a metallurgical change due to the welding heat. Fatigue failures initiate at the interface and are not visible on an assembly until complete failure is about to occur.

The important design factors are overlap, spot spacing, spot strength, and accessibility. Rules of thumb can be used for approximations. Cleaning prior to welding ensures uniform surface conditions and improves the consistency of welds. Optimum welding procedures are necessary for highest-quality welds. Deviations from the optimum will result in decreased strength, more inconsistencies, and increased internal defects.

There are no known non-destructive tests for spot welds that are totally reliable. Of the several destructive tests, the peel test offers the simplest and most effective single test.

Coated steels, such as galvanized steel, cadmium- and tin-plated steel, and aluminized steel, can be spot-welded with varying degrees of difficulty.

An Approximate Analysis giving Design Data for Corrugated Pipes

By P. J. PALMER
From an advance copy of a paper received from
The Institution of Mechanical Engineers, London,
April 1960, 7 pages, 2 illustrations.

IN order to consider the design of gas circuits which rely upon the flexibility of corrugated pipes or ducts under end load and bending moment, some general design data in a simple form are required. Generally, these corrugations will be small compared with the pipe size, and the shape of the corrugation has a cross-section made of circular arcs or of a very similar shape.

Of various methods proposed for calculating the stresses and deflections in corrugated pipes or ducts and expansion bellows, an approximate energy solution has been used by Salzmann. As applied to corrugations, this method deals only with the case of the deflections for a semi-included angle of 90 deg., but the solution is capable of extension to stresses and other cases. The solution proposed in this paper is an adaptation of Salzmann's method, and is modified and extended to cover any included angle of the corrugation, and the stresses as well as extensions are evaluated. A total of five cases, each with a different included angle, is evaluated in detail for both deflection and stresses. In fact, the method is applicable to corrugations of any included angle, provided that the radius of curvature of the corrugation is small compared with the radius of the pipe. The analysis is carried out using the principle of minimum strain energy, employing the smallest possible number of terms.

The advantage of the method is that results giving extension, bending stress, and circumferential stress can be evaluated for corrugations with different included angles, and can be simply presented in graphical form. These results are then readily available for design considerations covering corrugated pipes with internal pressure, axial load, and bending moment.

The approximate results are compared, where possible, with some results from more precise methods of analysis, and also with some experimental results, and the comparison shows the present method to be sufficiently accurate for design considerations.

The Electro-Gasdynamic Motion of a Charged Body in a Plasma

By L. KRAUS and H. YOSHIHARA
From *Journal of the Aero/Space Sciences*, U.S.A.,
Vol. 27, No. 3, March 1960,
pp. 229–233, 9 illustrations.

GAS DYNAMICS has generally been concerned with the motion of bodies through compressible fluids. In recent years, there has been renewed interest in a fluid which differs in many of its properties from an ordinary gas, i.e., a plasma, which is an electrically neutral gas containing ions and electrons. The possibility of affecting the properties of plasma flows by means of external magnetic fields has stimulated an extensive literature in aeronautical magneto-hydrodynamics; this paper, however, considers the motion of a body through a plasma where electrostatic phenomena are significant.

The motion of body in a plasma will, in general, induce a negative charge on the body, owing to the fact

Dielectric Heating - 2

The ability of dielectric heating to generate heat through the mass of a suitable material provides the following considerable advantages over other heating methods.

1. A body of uniform section and composition is heated uniformly throughout. Hence there is no waiting for heat to be conducted to the centre of the body, and this is of particular advantage when the body is thick and, as is often the case with dielectric materials, has poor heat-conducting properties.

2. The rate of heating can be faster than by external heating methods.

3. Since there is no external heat source, overheating or burning of the surface of a heat-sensitive material is avoided.

4. Heat input and heating time can be positively controlled.

5. High thermal efficiency is achieved.

6. Production can start immediately after switching on, and no current is used, nor heat lost, during periods of shut-down.

7. Vastly increased productivity is obtainable with less labour (usually unskilled), and fewer machines and less floor space are required.

8. Dielectric heating provides flexibility of layout and can be inserted directly in the production line.

Dielectric Heating: typical application data

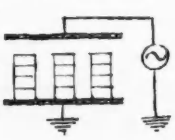
Typical application	Frequency	Radio frequency power
Thermoplastic welding.	20-100 Mc.p.s.	Up to 1 kW
Plastic preheating, wood glueing.	10-40 Mc.p.s.	2-30 kW
Plywood manufacture.	2-10 Mc.p.s.	Above 30 kW

Note: 1 Mc.p.s. = 1,000,000 cycles per second.

A few of the industrial applications of dielectric heating are briefly described below.

Preheating Thermosetting Plastics

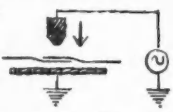
Dielectric heating is ideal for preheating pellets used for thermosetting plastic mouldings, which are poor heat conductors. It promotes faster curing, reduces moulding time and can increase production 10 to 15 times. Tool wear and damage to metal inserts are reduced, and thicker sections can be moulded.



Welding of Thermoplastic Materials

An important and extensive application of dielectric heating is the welding of thermoplastic sheets in the fabrication of such commonly used articles as raincoats, hoods, handbags, pouches and packaging materials. Dielectric heating is the only method which can usefully be employed, since the heating electrodes, and hence the outside sheet surfaces, remain cool while the inside surfaces forming the joint are fused, and a perfect weld results.

Two or more thermoplastic sheets are welded under pressure from electrodes suitably shaped to the area of weld required, the current being switched on at the same time as pressure is applied, and off when the weld is completed and the pressure released. Stitching is thus eliminated and a far stronger joint achieved.



In some cases, a suitably profiled electrode can be fitted with a knife edge to cut the sheets immediately outside the weld line, welding and pattern-cutting being thereby carried out in the one operation. Dielectric welding can be applied also to very large thermoplastic products such as linings for swimming pools, and cinema screens.

Drying

Drying of materials by dielectric heating has the great advantage that the material tends to dry out from the centre, the reverse of what happens when external heating methods are employed, and the risk of overdrying and overheating of the surface is eliminated. While the removal of large amounts of water from inexpensive commodities may sometimes be uneconomical, dielectric heating in the production line often leads to a higher overall production efficiency. It is valuable for removing final moisture traces and becomes increasingly economical as the value of heat-sensitivity of the commodity increases.

For further information get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. Tel: TEMple Bar 9434.

Excellent reference books on electricity and productivity (8/6 each, or 9/- post free) are available — "Induction and Dielectric Heating" is an example.

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that the relative flux of the electrons to the body is greater than that of the ions. This charge will then affect the flow through the Coulomb interaction with the plasma. A charge may also be induced on a body by entirely different or even artificial mechanisms. The motion of charged bodies in a plasma is what has been called " electro-hydrodynamics ", or, since a plasma is generally a compressible fluid, " electro-gasdynamics ".

This paper reviews briefly the basis for treating a plasma as a fluid to which hydrodynamic considerations may be applied, and then describes briefly the basic equations and illustrates the theory by treating the very simple case of the supersonic flow of a plasma past a two-dimensional slender dielectric body. This simple example indicates some of the aspects of the coupling between the fluid motion and the electrostatic properties of a plasma. The simplication requires an absence of the effects of boundary layers, i.e., of narrow regions in which the electrostatic potential and the flow properties change rapidly. In a more general case, important modification must therefore arise near the body. The precise analysis of these effects would require the use of the complete fourth-order system of differential equations. These equations are twofold hyperbolic and twofold elliptic when the motion of the body is supersonic with respect to the ion thermal velocity. This property manifests itself, for example, by an upstream effect ahead of the leading edge Mach wave which damps exponentially. Electrical effects, instead of influencing the entire medium, are confined essentially to a region downstream of an electrostatic Mach envelope. Along these Mach envelopes, charge separation takes place which provides an interesting modification of the flow that may be observed experimentally.

The dense plasma case treated in this paper is, of course, not directly applicable to the motion of a charged body in the rarefied ionosphere. In the latter case, " fluid-type " equations also arise when the molecular collisions due to short-range forces are neglected, and a treatment similar to the dense case may be carried out.

Developments and Trends in Plant Instrumentation

(Concluded from page 106)

tances is already becoming more apparent. So, too, is the long-distance remote control of power plants, pumping stations, booster points using gas-turbine-driven compressors in natural-gas pipelines, etc. Certainly, it seems likely that, in the future, there will be automatic distribution systems for electric power, towns gas, water, and other amenities from public-utility companies.

Although closed-circuit television is now being quite widely used for industrial purposes, it seems safe to predict that it will be much more extensively used in future instrumentation than it is to-day. The use of one or several television cameras many miles away from the location of a receiver mounted on the central instrument panel of a remotely controlled power or pumping station may well become standard (Fig. 6). The more extensive use of the microwave transmission of images on monitor screens forming part of a graphic panel is certain to come, as also is combined television and telephone equipment.

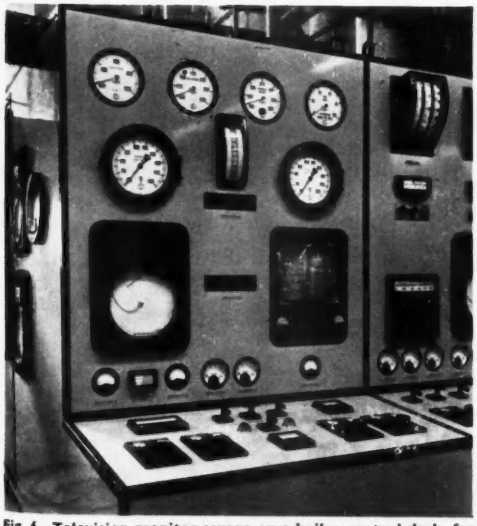

Fig. 6. Television monitor screen on a boiler control desk, for displaying water level.
(Courtesy of Marconi's Wireless Telegraph Co. Ltd.)

The future of computers for process work seems very promising, provided that the already visible trends for simplification, miniaturization, and easier handling can be maintained, and the cost price brought down to within the reach of medium-sized plant.

Plant Instrumentation and Personnel

It is obvious that the best plant instrumentation will deteriorate if instruments are not properly serviced. Efficient plant management has certainly the desire to provide what is called preventive maintenance in which regular inspection and repairs are performed during the working life of each instrument. The difficulties are often the lack of skilled maintenance workers and supervisors, and various methods have been suggested for overcoming the deficiency of adequate instrument maintenance crews. Thus, large works take in apprentices and train them in their own instrument department, while medium-size and smaller firms make use of maintenance schemes run by prominent instrument makers, mainly for their own instruments.

In recent years, a number of specialized instrument maintenance firms have become available for taking over the responsibility of keeping plant instrumentation in perfect order. It is hoped that their number will increase as the number of new systems becomes bigger.

As far as the operation and servicing of computers is concerned, the demand for skilled programmers and skilled maintenance staff is very high indeed. At the present time, maintenance staff is often provided by the manufacturers of computers, but, as the number of machines increases, the demand will probably become too big to be met. A skilled programmer must be half mathematician and half process engineer when dealing with process-control computers, and such men are rare.

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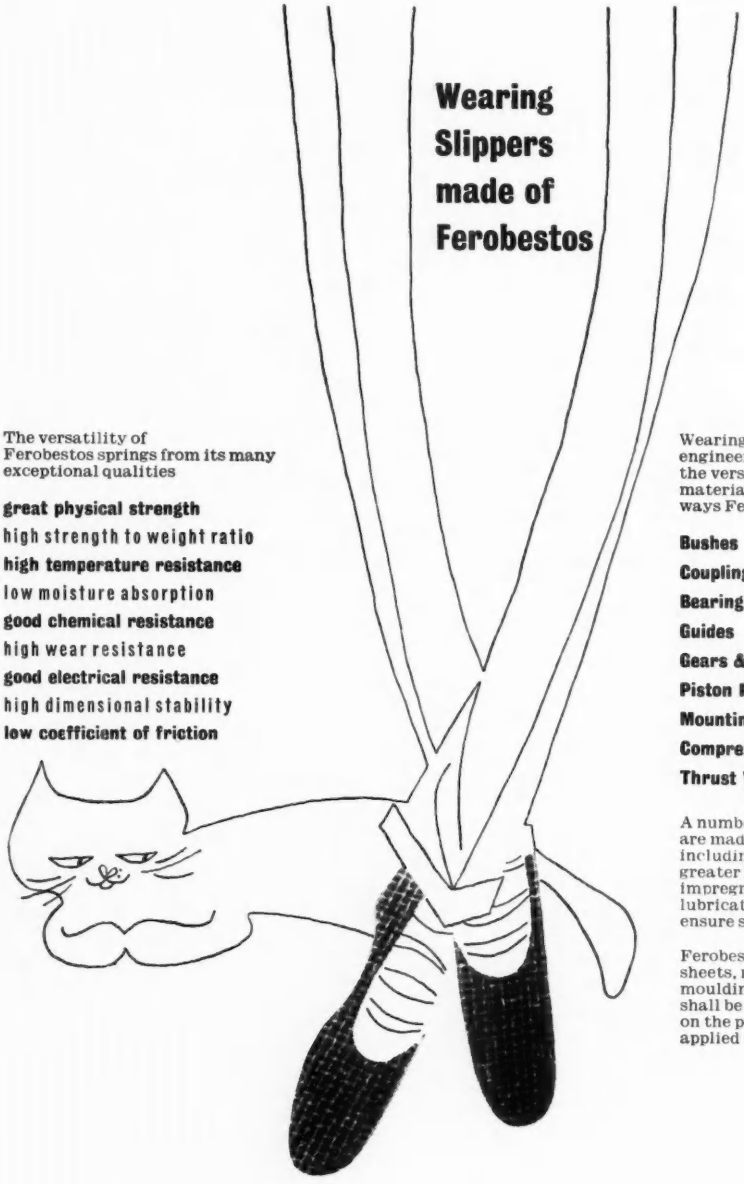

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New Materials, Processes, and Equipment

In-Line Viscosity Controller

Primarily developed to satisfy a requirement of the petroleum industry for equipment capable of maintaining the viscosity of various grades of fuel oil within very close limits, the new in-line viscosity controller (Fig. 1) developed by Smiths Industrial Division, of London, N.W.2, provides continuous control of blending processes with such precision that it is possible to guarantee the viscosity of the blend to within 1%. In addition, it is stated that the use of this controller saves from 3 to 4% per ton on the cost of making an oil blend. The principle of operation is that, by the use of two viscometers, the viscosity of a sample from a pump line is continually balanced against the viscosity of a sample prepared in the laboratory. The viscosity of each sample is measured by a rotating-cup viscometer, the output torque of which acts upon a balance-arm. As it is impossible for two viscometers to have exactly the same gaps between the moving and static elements, an adjustment is provided for the fulcrum of the balance-arm, identical samples being run through the viscometers while adjustment is made to achieve this balance.

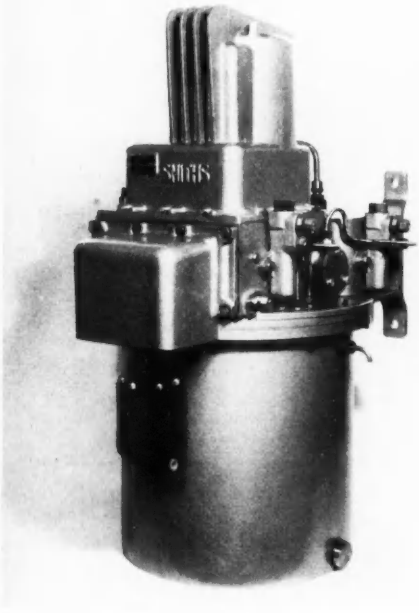

Fig. 1.

In operation, a standard sample having the desired viscosity of the product is fed by gravity through a filter and introduced into the sample viscometer through the pipe (1) shown in Fig. 2, whence it passes to the lower bearing spigot and cross-passages and then to the space around the outside of the rotating drum. Finally, it enters through peripheral holes drilled around the mid-point and fills the annular space between the rotating drum and the measuring drum.

Oil from the blending line enters the strainer (2) through the pipe connection (3), and thence flows through the pipe (4) to a pump. The strainer has a very small capacity, as a large capacity would unduly delay the signal indicating change of viscosity. The pump (5) is introduced mainly to isolate the apparatus from line pressure. Oil passes through the pump, enters a heat exchanger via the pipe connection (6), and then flows through the connection (7) into the in-line viscometer. The heat exchanger is provided to ensure that oil from the line is raised to the same temperature as that of the standard sample in the shortest period possible, i.e., approximately five seconds. The heat exchanger consists basically of two concentric metal sleeves. Oil from the line is forced through the annual space between them, whilst water is circulated by means of the impeller (27) through the inner sleeve and the water jacket surrounding the outer sleeve.

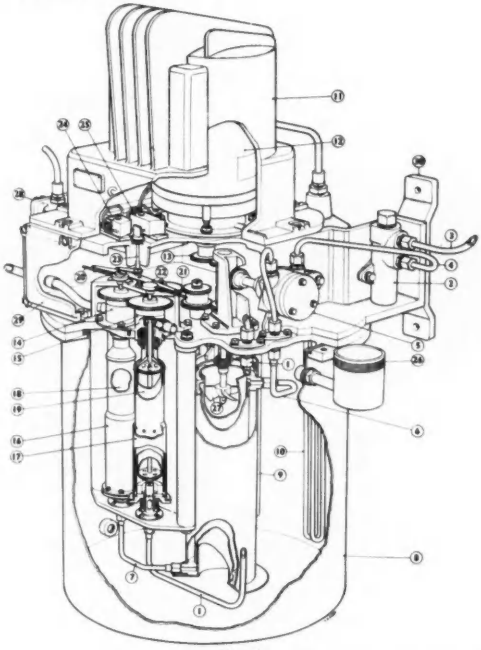

Fig. 2.

The temperature of the water bath (8) is maintained by means of a thermostat (9) governing a heating element (10). The exact temperature is not important, but is set to a figure which ensures that the viscosity of the line

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sample, and hence the torque produced at the viscometers, is not unduly high for the type of mechanism. Water is used for the bath and, in conditions where extremely low temperatures may be expected, an anti-freeze solution is recommended. The water bath is topped up through the filling cap (26).

The electrical side of the controller is of flameproof construction. The top cover (11) is cut away in the diagram to reveal the motor (12) driving the spur wheel (13), which in turn drives the pump (5) and rotating outer sleeves (14 and 15) of the viscometers. The oil then passes to the viscometers, where rotation of the outer cylinders (16 and 17) causes a viscous drag on the inner, or measuring, cylinders (18 and 19). This torque is applied to the arms (20 and 21), which act upon the balance-arm (22). Excessive stresses are obviated by the use of lengthy arms, so that frictional forces on the central pivot of the balance-arm are minimal. Motion of the balance arm is transmitted through the shaft (23) to operate the micro-switches (24 and 25).

An important constructional point is the method of sealing the shafts from the sensitive cylinders to the balancing mechanism. In this application, it would be quite valueless to provide conventional seals because, with some low-viscosity products, an out-of-balance torque of a mere 2 grams would represent a viscosity change of 1%. A novel method of construction causes the oil to be discharged from the viscometers without creeping up the shafts.

The viscosity controller depicted in Fig. 2 is a simple "On-Off" electrical type, and the micro-switches in this application would be used to control a relay box and hence a motorized control valve in the blending unit. For pneumatic control, the micro-switches would be eliminated and replaced by a drive taken from the balance unit by bevel wheels to a pneumatic controller. The terminal box (28) is of flameproof construction. Access to the mechanical balancing unit can be gained by removal of the cover (29). It is recommended that the controller be bolted to a wall or similar structure by brackets (30), and at sufficient height to enable the water container to be removed for inspection of the mechanism.

Hydraulic Nuts

The new range of "Euco" hydraulic nuts announced by Euco Tools Ltd., of Kingston, Surrey, has been developed with a view to obtaining greater pressure with considerably less effort and, at the same time, to eliminate the torsional strains inevitably present when tightening nuts by conventional methods, in which the resulting pressure depends on the length of the wrench used and the applied force, as well as very often the slight additionals effects of heavy hammer blows on the wrench to obtain the maximum possible pressure.

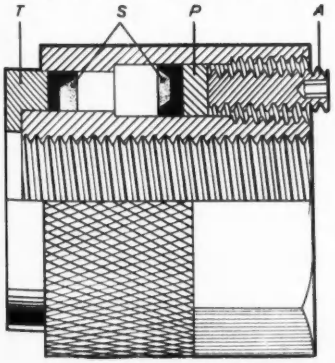

Fig. 1.

Fig. 2.

The body of the nut (Fig. 1) is constructed of high-tensile steel, with an annular recess formed in the front face. This recess communicates with a bore passing through to the rear face, the bore being threaded to receive a reducing bush which accommodates a pressure screw *A*. The recess and bore are filled with a special compound and are enclosed with seals at *S*. A thrust ring *T* fits into the recess, bearing against the front seal, and a pressure pad *P* bears against the rear seal and transmits the pressure applied by the screw *A*, which is operated by means of an Allen key, as shown in Fig. 2.

To illustrate the efficiency of these nuts, tests have shown that, when a 1-in. hydraulic nut is screwed on by hand to an initial pressure of about 0·3 tsi, the pressure can easily be increased by 4 tsi by turning the Allen key held between a finger and thumb. Removal of the nut is equally effortless, unscrewing the pressure screw releasing the pressure and enabling the nut to be removed by hand. Similarly, when the nut is applied with a spanner to an initial pressure of 1 tsi, it is just as easy to increase the pressure to 5 tsi by turning the Allen key.

At present, these nuts are being produced in all sizes from ⅜ to 2 in. in diameter and with Whitworth, American, unified, and metric threads. However, larger sizes, as well as special-purpose nuts, capable of providing pressures up to 10 tsi, can be made to order.

Fixed-Prod Tester for Low-Voltage Ranges

Introduced specifically to meet a demand for a means of testing the lower voltage ranges, a new fixed-prod tester for work on circuits from 24 to 100 V has been introduced by the Electrical Equipment Division of the Martindale Electric Company Ltd., of London, N.W.9. In common with the standard Martindale fixed-prod testers for the range up to 600 V, the new low-voltage tester incorporates one of the prods actually in the body of the tester, making it easier to use.

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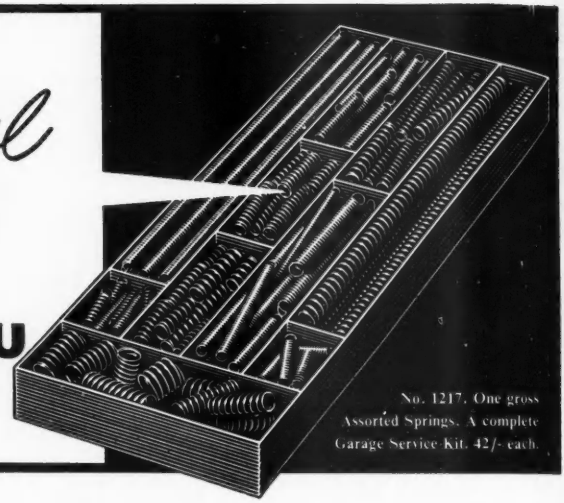

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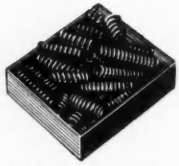

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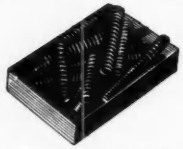

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HT50C

The bobbin is constructed of moulded nylon and contains over a mile of wire, providing a high resistance and a low rating. The coil ends are attached to moulded-in terminals, into which the cable is screwed. Pulling on the lead cannot affect the coil. A built-in magnifier makes the indicating easy to read. The prods are of special design, in that spring-loaded sheaths normally cover the points, and these are pushed back when the prods are held against the surface under test. The sheath of the search-lead prod can be held back slightly by a bayonet action. Inside the prod is a 2-A fuse of high rupturing capacity, in series with a current-limiting resistance of 5 ohms.

An advantage of the design is that, if the tester is momentarily connected with a circuit of too high a voltage for its capacity, it will sustain no damage. In such cases, on both a.c. and d.c. supplies, the indicator disc will show that a tester with a higher voltage range is required; in addition, on a.c. supplies, the tester will vibrate violently.

Ultrasonic Cleaning Equipment for Small Parts

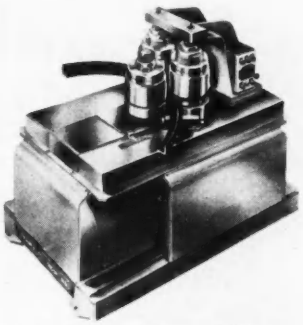
Basically intended for the ultrasonic cleaning of small parts, such as watch and clock components, quartz crystals, transistor and valve elements, printed circuits, relays and switches, and precision gears, lenses, and ball bearings, the latest addition to the range of ultrasonic cleaning equipment produced by Dawe Instruments Limited, of London, W.5, is their type-1156 "Soniclean" generator, which operates at 40 kcs and has a peak power output of 250 W.

Two types of barium titanate transducer are available for use with this generator, i.e., the type-1161/B18 stainless-steel immersible transducer, or the type-1160/T24 self-contained unit, in which the radiating elements are assembled in the base of a stainless-steel cleaning chamber. The overall dimensions of the immersible transducer are $7\frac{1}{2} \times 2\frac{7}{8} \times 2\frac{3}{4}$ in. high, and those of the self-contained unit $7\frac{3}{4} \times 4\frac{1}{2} \times 8\frac{1}{4}$ in. high, the dimensions of the actual cleaning chamber being $7 \times 3\frac{1}{2} \times 5$ in. high. Both types of transducer are capable of ultrasonically agitating $1\frac{1}{4}$ litres of cleaning solvent and can be used with liquid temperatures up to 160°F, operation at between 100° and 160°F being recommended for most cleaning applications. However, high-temperature applications can, if desired, be carried out by keeping the hot solution in a separate inner container and transmitting the ultrasonic energy through a water bath fitted with cooling coils. The output of the generator can be switched to either of two output sockets, permitting alternate cleaning and rinsing.

Rolling Machine for Steel Sections

Designed specifically for the rapid forming of rings, the new "Besco" horizontal steel-section rolling machine announced by F. J. Edwards Limited, of London, N.W.1, is of extremely robust construction and utilizes two main driving rollers and a power-operated adjustable pressure roller, as well as a pair of adjustable hardened guide-rollers for supporting the work while rolling.

The two main driving rollers are supported by an overhead bracket to prevent deflection, while the third adjustable pressure roller is mounted on a heavy steel slide in taper roller bearings, to permit free rotation under the heaviest loads. The drive to the main driving rollers is from a high-torque 5-hp reversing motor through spur gearing to an enclosed worm gearbox, whilst the adjustment to the pressure rollers is through a separate 2-hp reversing motor and worm drive to a powerful square-thread leadscrew, enabling the operator to make initial bends in the heaviest sections before rolling. For repetition rolling, an adjustable limit-switch and gauge is provided on the adjustable roller slide. Both motors are fitted with magnetic brakes to ensure positive control. A central panel contains forward, reverse, and stop push-buttons for the pressure-roller motor, and start/stop buttons, together with an indicator light, for the main driving motor. A joystick controller provides for reversing the drive rollers.



The standard rollers, 10 in. in diameter, are adjustable to accommodate all standard rolled-steel sections, i.e., angles, tees, channels, rounds, squares, and flats, the capacity of the machine being as follows: Angles and tees up to $2 \times 2 \times \frac{1}{4}$ in. (leg in) and $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{3}{8}$ in. (leg out), with respective mimimum diameters of 18 and 24 in.; channels up to $4 \times 1\frac{1}{2}$ in. (flange in) and 4×2 in. (flange out); rounds up to $1\frac{1}{2}$ in. diameter; squares up to $1\frac{3}{4}$ in.; and flats on edge up to $2\frac{1}{2} \times \frac{1}{2}$ in.

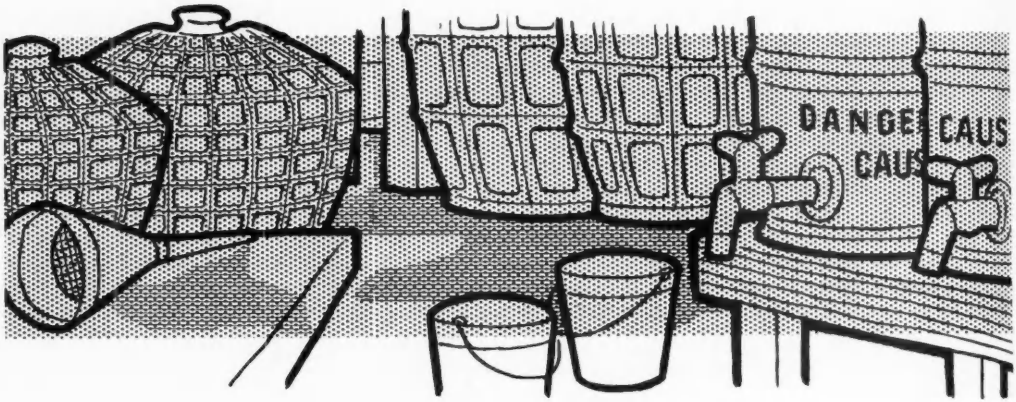
General-Purpose Vacuum-Pumping Unit

Designed to afford users in both industrial and laboratory applications the advantage of obtaining a high vacuum from a fully automatic unit having single-lever operation control, the new general-purpose vacuum-pumping unit announced by N.G.N. Electrical Ltd., of Accrington, is fully protected against power failure, accidental stoppage, or a drop in water pressure. Two sizes of unit are available, designed to produce a vacuum of better than 5×10^{-6} mm Hg with a pumping speed of over 23 litres/sec, or 1×10^{-4} mm Hg with a pumping speed of 100 litres/sec.

In the event of accidental stoppage or power failure, the unit is automatically isolated, so that damage cannot be caused to the plant or any apparatus in the vessel being evacuated. Thus, if the plant is positioned on fine-pumping and the power supply is inadvertently shut off, the backing line is closed by a magnetic isolation valve and air is automatically admitted through an air-admittance valve, the operation of these two valves being delayed by a 2-sec time-dwell, preventing oil from being sucked out of the rotary pump into the backing or roughing line. When the electrical supply is reconnected, the air-admittance valve closes and a time-lag occurs, allowing the backing or roughing line to be pumped down before the isolation valve opens. Consequently, the vacuum in the vessel is maintained, and hot oil in the diffusion pump does not come into contact with atmo-

SPLASH AND SPRINKLE –

DRIP AND SPILL



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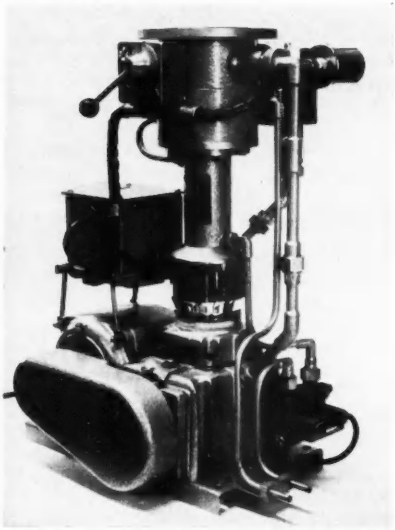
sphere. If the cooling water to the diffusion pump is inadvertently cut off, a red-light indication is given to the operator, and the heater to the diffusion pump is automatically shut down. The diffusion pumps are of the fractionating type, and the backing pumps are gas-ballasted to permit evacuation of chambers containing condensible vapours.



The operating handle has four positions, i.e., rough-pump, fine-pump, isolation, and air-admittance, a quadrant movement separating these four positions. When the unit is set on rough-pump, the vessel being evacuated is pumped down to approximately 350 microns before fine-pump selection occurs, bringing the diffusion pump into circuit. At this setting, the rotary pump acts as the backing pump. The isolation position of the level isolates both pumps from the vessel, and, on air admittance, a magnetic valve is actuated, permitting air to enter the evacuated vessel. The unit is then ready for another cycle of operations. It is not necessary to operate the handle in the full cycle of movement, since it can be turned clockwise or anticlockwise through 180 deg. in one movement, i.e., from rough-pump to isolation, without harming the unit or apparatus.

Compact Rotary-Operation Switchgear

By breaking away from conventional design approaches and developing switchgear of unusually attractive appearance, excellent performance, and small size, the General Electric Co. Ltd., of London, W.C.2, has produced a range of units which can be used in installations where the appearance of conventional industrial switchgear would not be acceptable. The new range, designated G.E.C. " Hidutac ", is at present available in ratings of 400 V, a.c. 15, 30, and 60 A, with either H.R.C. or semi-enclosed rewireable fuses, and is stated to be capable of unlimited full-load switching, this claim being based on tests which have shown that the units are still in good working order after 100,000 mechanical operations and after 50,000 operations at 50% overload when controlling a tungsten lamp load with a high inrush current.

This exceptional performance is achieved by the use of cam-operated slow-break solid-silver contacts, the switch element for each phase being individually enclosed to give maximum protection against flash-over. The switch mechanism and fuse bases are moulded in single-piece porcelain units, which are enclosed in deep-drawn steel cases, fitted with P.V.C. gaskets. Control is effected by a front-operated rotary handle moulded in toughened polystyrene. Normal interlock between cover and base, together with the complete internal enclosure of all moving parts, ensures safety. In addition, live incoming terminals are fully shielded by screens marked " Live Terminals ".

Low-Density Aluminium-Foam Materials

Made from various aluminium alloys, a new range of low-density aluminium-foam materials, designated " Foamalum ", has been developed by The Foamalum Corporation, of La Salle, Illinois, and can be cast into fairly intricate shapes with a reasonable control of density between 20 and 70 lb/cu ft, as compared with the density of about 166 lb/cu ft of ingot aluminium. In the casting process, a " skin " of comparatively smooth aluminium is formed where the mould is contacted, the core consisting of foamed aluminium, the cells of which are smaller near the surface of the casting. The lowest-density material (20 lb/cu ft) is obtained by removing the heavier skin surface from the casting by sawing or machining.

The physical properties of the material vary according to the aluminium alloy used and, for any given alloy, the tensile and compressive strengths are nearly proportional to the weight of the foam, compared with the weight of the ingot metal used. " Foamalum " has good malleability and good rigidity, though no exact measurements have as yet been obtained. It floats on water, not because of its skin surface, but because a major proportion of the cells or bubbles are closed and will not absorb water, even with the skin removed from the casting, as shown in the illustration. Furthermore, it can be pressed into various shapes without destroying the cell structure and with little or no splitting or shattering of the material, the only effect of such operations being to change the shape of the cell. It should also be noted that, as the material is compressed, its strength increases, and preliminary tests with softer, less brittle alloys indicate that the original ingot strength is obtained when only 50% of the original density has been reached.

With regard to the thermal conductivity of " Foamalum ", tests on one sample with a density of 40 lb/cu ft have indicated a value of about 17·7 BTU in./sq ft/hr/°F, as compared with 1450 BTU/in./sq ft/hr/°F for the original ingot. Thus, the foam material has a heat loss

Do you wait for hot water on a cold Monday morning?

Where hot water is provided from a storage system there is a waiting period when production starts, for the water to heat up in the storage tanks.
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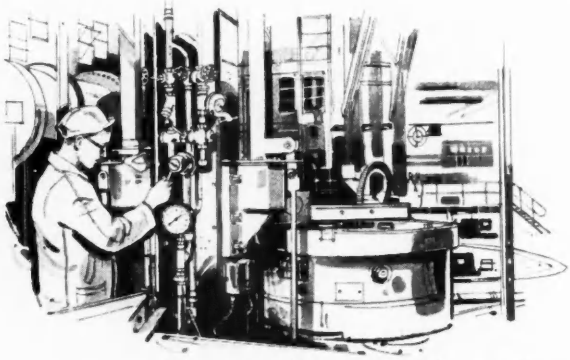
Do you use cold water when you would like to use hot?

When vegetables are cleaned for canning they are washed in a running stream of water. If the water is too cold the girls' fingers get numb and their production slows down. If it is too hot the vegetables are spoilt. A Leonard Valve looks after the temperature, the girls' fingers and the vegetables.



These are specific examples. Your use of Leonard Thermostatic Steam Water Heaters will probably be different. Write for help. (Our folder H/24)

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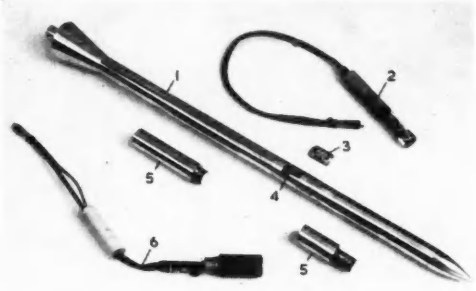
of a little over 1% and a density of about 25% of that of the solid material.

"Foamalum" can be machined and sawed, and nailed, bolted, or glued to other materials, and incorporates the usual advantages of aluminium, in that it is proof against rust, warp, fire, insects, etc. These properties, combined with its flotation properties, have opened up many potential applications, and it is already being considered for use in marine, missile, automotive, electronic, chemical, and constructional fields, including its use as a core material for doors, laminated panels, sandwich-type panels, acoustic tiles, and containers.

Nuclear-Density Altimeter

Especially intended for use in high-altitude jet aircraft, a new type of altimeter which "bounces" nuclear energy against rarefied air to achieve high-accuracy altitude readings has been developed by the Boeing Airplane Company, of Seattle, Washington. In this connection, it has long been known that the density of liquids passing through a pipe can be determined by directing penetrative radiation into the stream and measuring the radiation deflected by the collision. In the new altimeter, a similar technique is adopted for measuring varying air density, and this is the essential difference between the new nuclear-density or radioisotope-density altimeter, as it has been designated, and conventional instruments which indicate altitude by measuring atmospheric pressure. At the same time, however, it should be appreciated that pressure altimeters are still the most reliable instruments of their kind for the relatively turbulent air levels below 25,000 ft, where air density is less stable, as the horizontal pressure gradients are narrow and hence can indicate altitude with greater accuracy. Above 25,000 ft, in the region known as the isopycnic level, the density gradients become narrower and the pressure gradients widen, so that, with increasing altitude, the error of mechanical pressure-operated instruments increases. On the other hand, with the new nuclear-density altimeter, the greater is the altitude the more efficient is its operation. It is for this reason that the new altimeter is not intended to supersede pressure-operated instruments, but rather to complement them. In fact, in modern jet aircraft, it is considered that both types are necessary, i.e., pressure-operated altimeters for use up to the isopycnic level, and nuclear-density altimeters above this level.



Essentially, the new altimeter, the major components of which are shown in the illustration, utilizes a probe (1), constructed of precision-machined aluminium or melamine tubing and mounted outside the aircraft, usually at a wing tip. Housed in a viewing window (4) in the probe, which can be fitted with extension nose-pieces (5), is a plastic scintillator detector (3) incorporating a radioactive source, emitting beta particles which are deflected by air particles. The rate of this deflection of particles back towards the probe, or back-scatter, is proportional to the density of the atmosphere. With an increase in altitude and a corresponding decrease in air density fewer particles are subjected to back-scatter, and this diminishing rate of return, detected by the scintillator (3), is sensed by a photomultiplier tube (2), passed through an amplifier (6), and counted on a scaler to provide an altitude reading on a dial.

The use of the new altimeter for measuring aircraft speed is being studied. In this case, the altimeter probe ahead of the wing measures the air density at flying speed, while a second probe, located in the boundary layer of static air formed by the leading edge of the wing, measures the "stagnant" density. A comparison of the two densities, indicated on a dial, gives the Mach number of the aircraft.

The Effect of Preheated Welding Wires on Welding Characteristics

(*Concluded from page 100*)

tion rate increases sharply as the length of wire extension is increased. Such an increase in deposition rate naturally would have to be accompanied by an equivalent increase in the rate at which the filler wire was fed into the arc.

(3) *Reduced Penetration without Impaired Bonding:* This principle can be utilized to reduce penetration sharply without impairing bond strength and can be useful in hard-surfacing or stainless-steel surfacing applications from the viewpoint of decreasing dilution, and hence of minimizing changes in the chemistry of the deposit.

(4) *Reduced Penetration of Mild Steel:* In the case of welds made on mild steel, decreased dilution, as offered by preheated wires, could minimize or eliminate the need for very highly deoxidized filler wires. For example, assume that the silicon content of the weld metal must be at least 0·15% to prevent rimming (gassing) of welds made on hot-rolled steel plate. Since the filler wire must provide sufficient silicon to maintain this level, dilution from the lower-silicon-content base material becomes an important consideration. If wire extension decreases the amount of penetration or dilution, it also decreases the need for high-silicon levels.

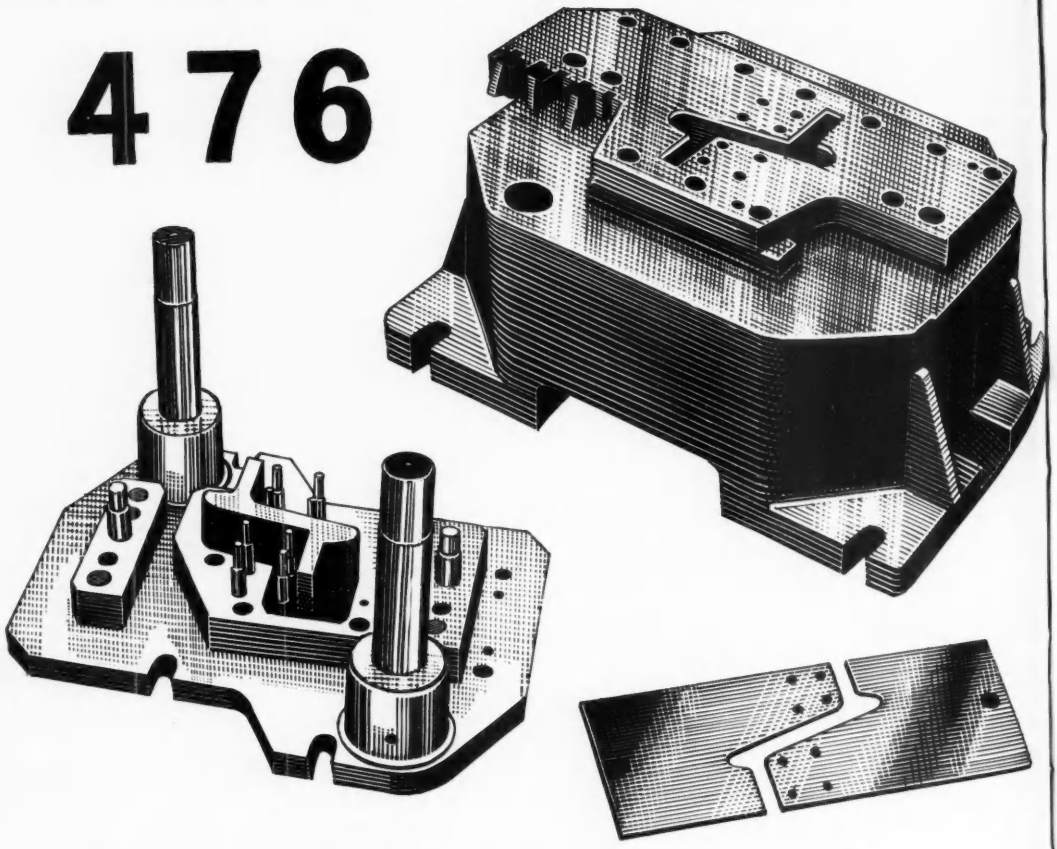
(5) *Improved Control of Operating Characteristics:* As the length of wire extension increases, metal transfer becomes more globular. In some cases, this change in metal transfer is accompanied by a decrease rather than the normal increase in the level of spatter.

Preheated filler wires often can be used successfully with short arcs and high welding currents without excessive penetration or poor bead contour. It is possible that, with this technique, thin-gauge materials could be welded at high deposition rates, where normal wire extensions would produce excessive, unusable levels of penetration.

It should, however, be noted that increased wire extensions are often accompanied by increased difficulty in starting the weld. If the wire freezes to the base plate, the entire extension heats very rapidly and may melt at any point along its length. Under such conditions, melting at other than the arc end could continue indefinitely. Thus, extra care and precautions are essential on striking the arc to ensure a good start.

SANDERSON tool steels

476



'476' Heavy duty die steel of the high carbon, high chromium type, has outstanding wear-resistance but is tough and machinable. It is particularly recommended for tools operating under conditions of severe wear and abrasion and where maximum runs are required.

The above illustrations show a punch and die set produced from '476' steel by The Mining Engineering Co. Limited, Worcester.

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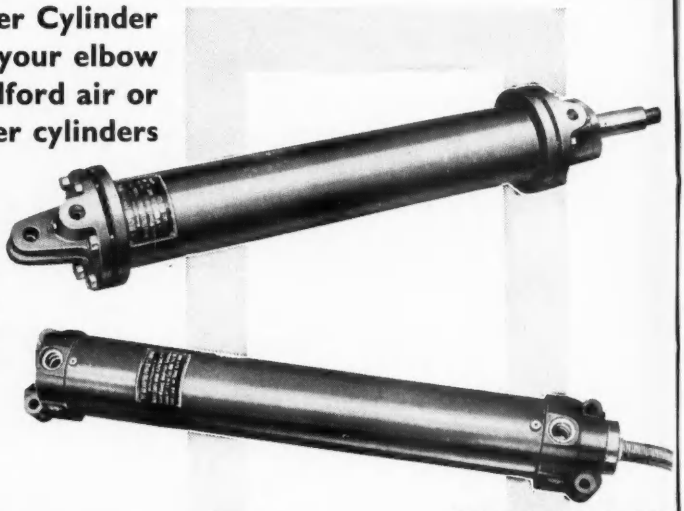

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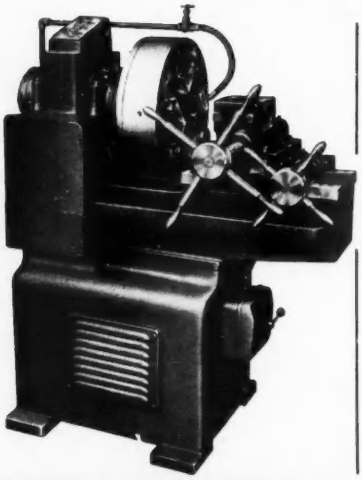

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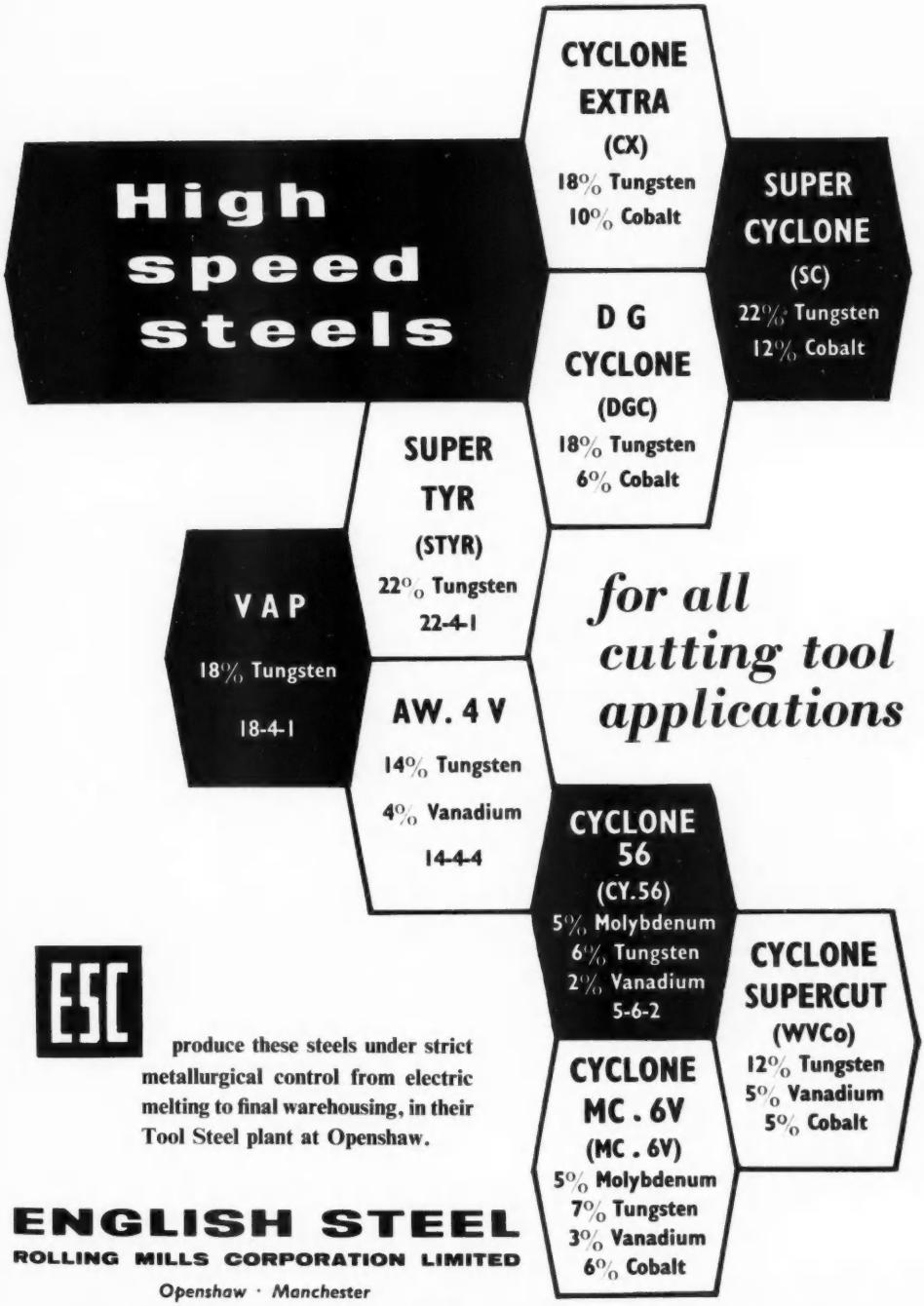

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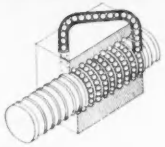

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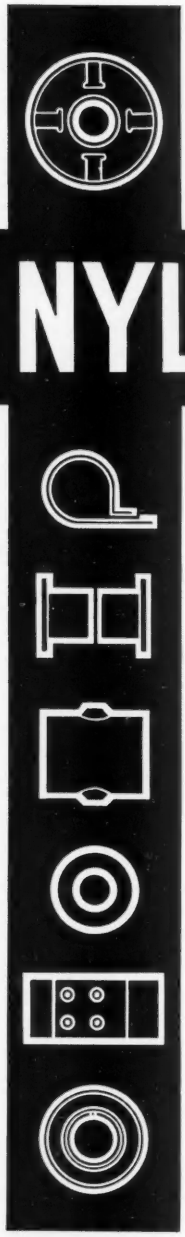

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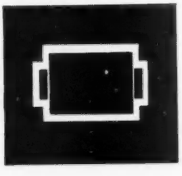

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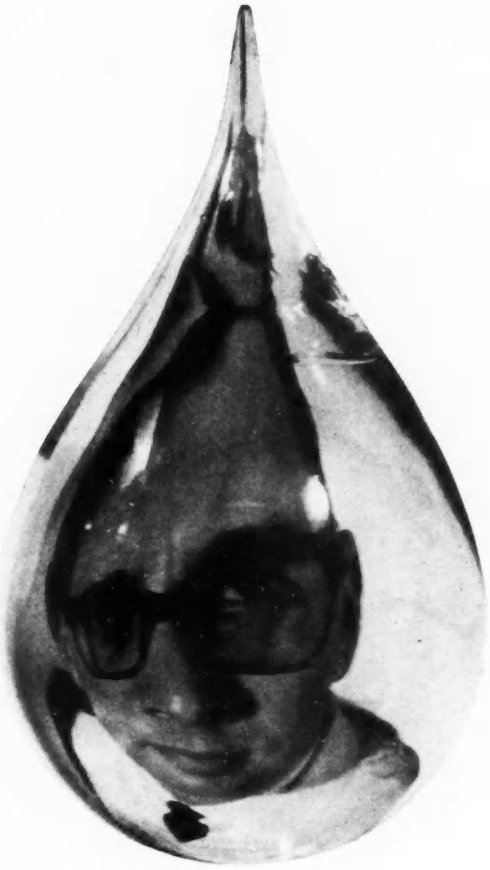

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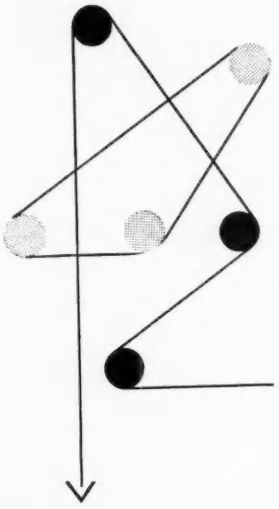

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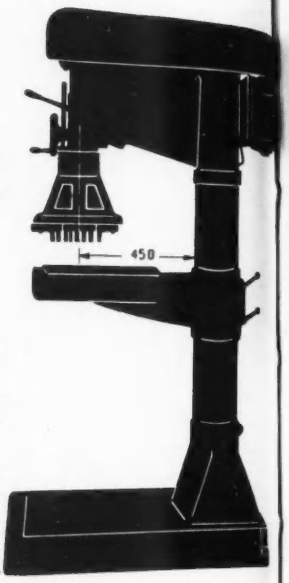

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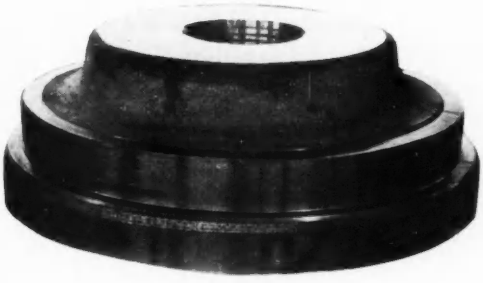

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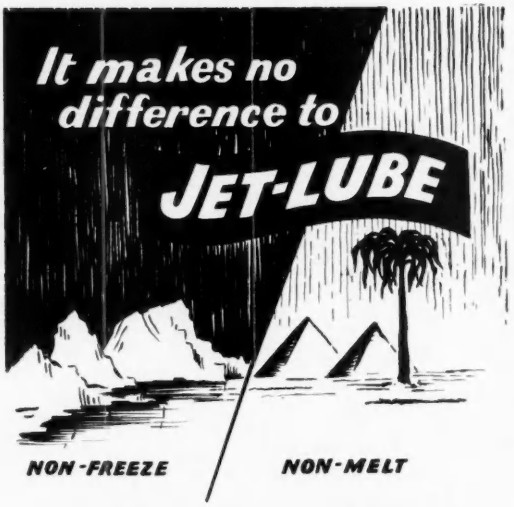

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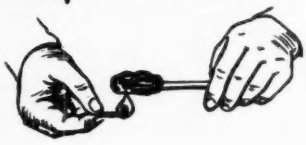

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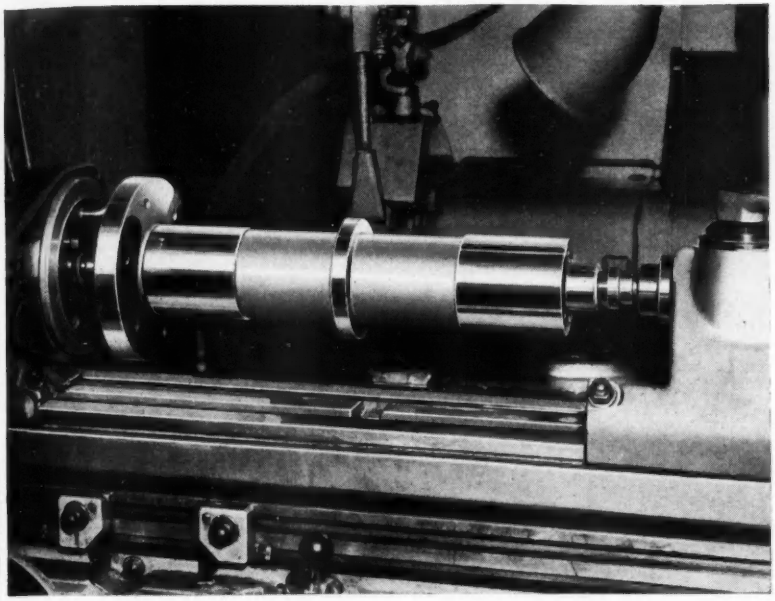

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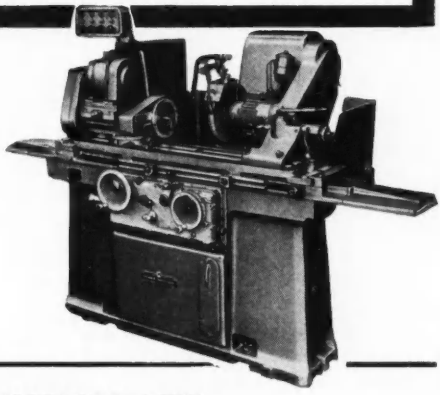

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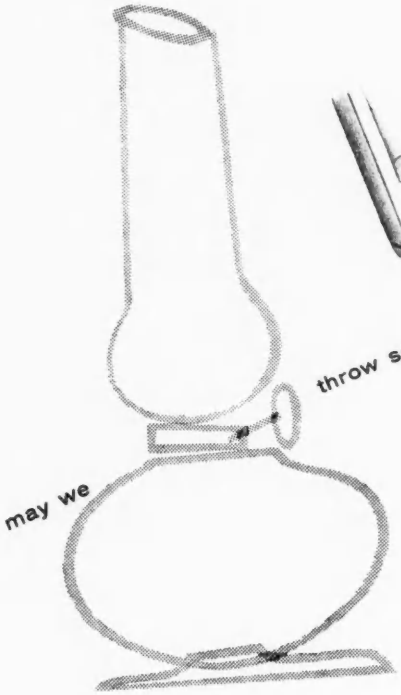

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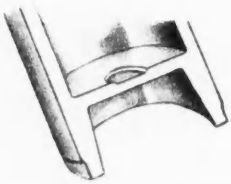

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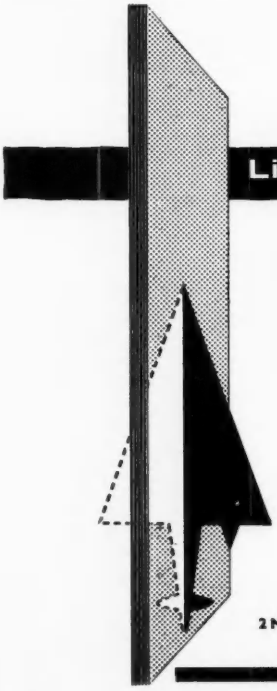

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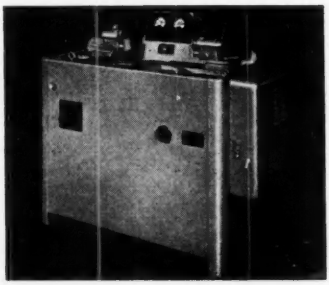

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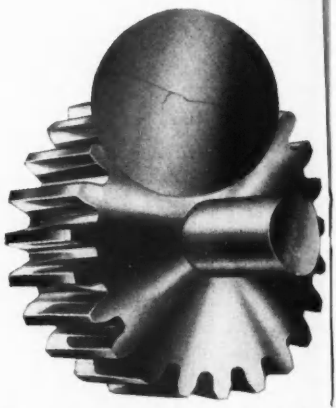

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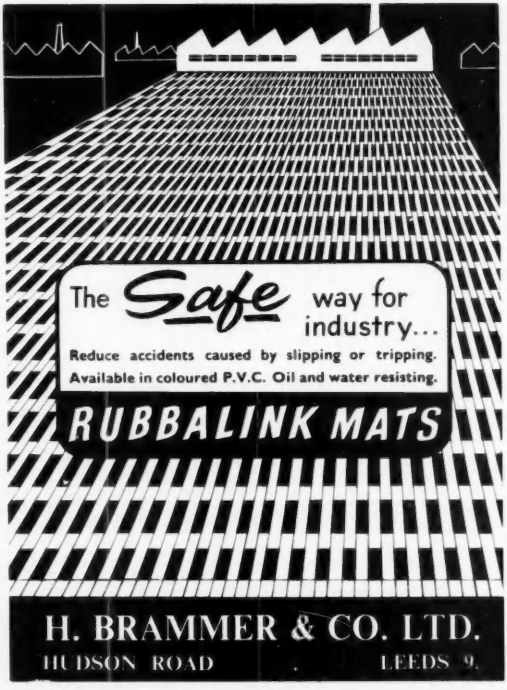
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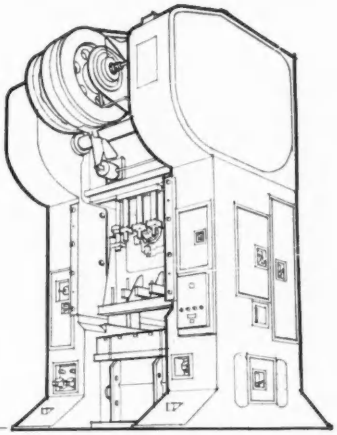

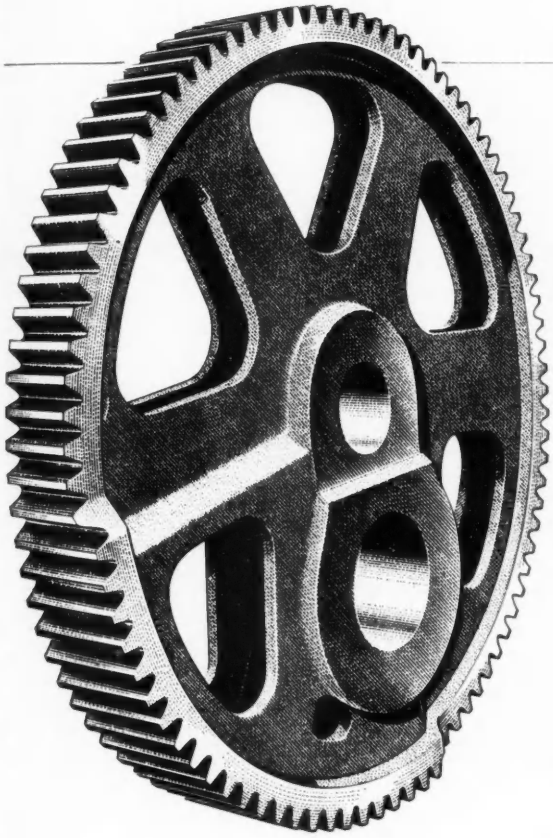

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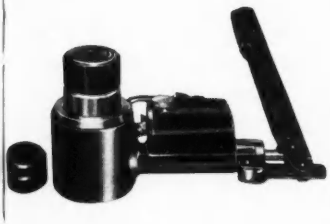

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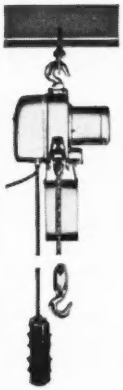

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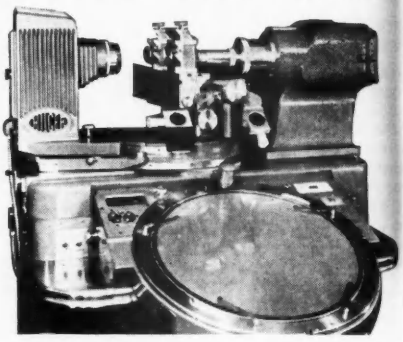

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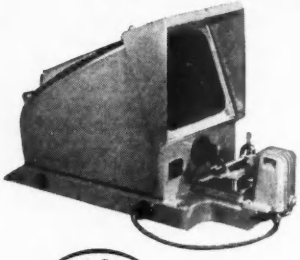

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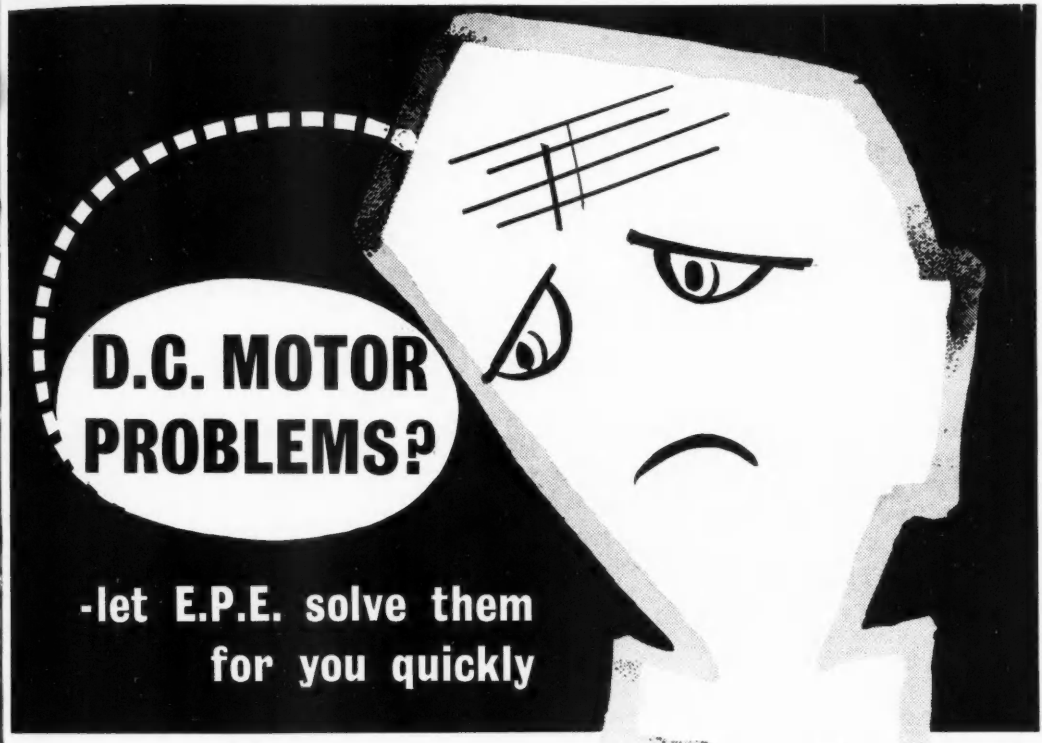

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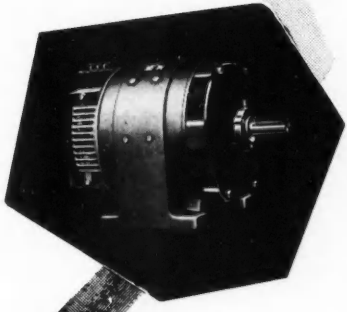

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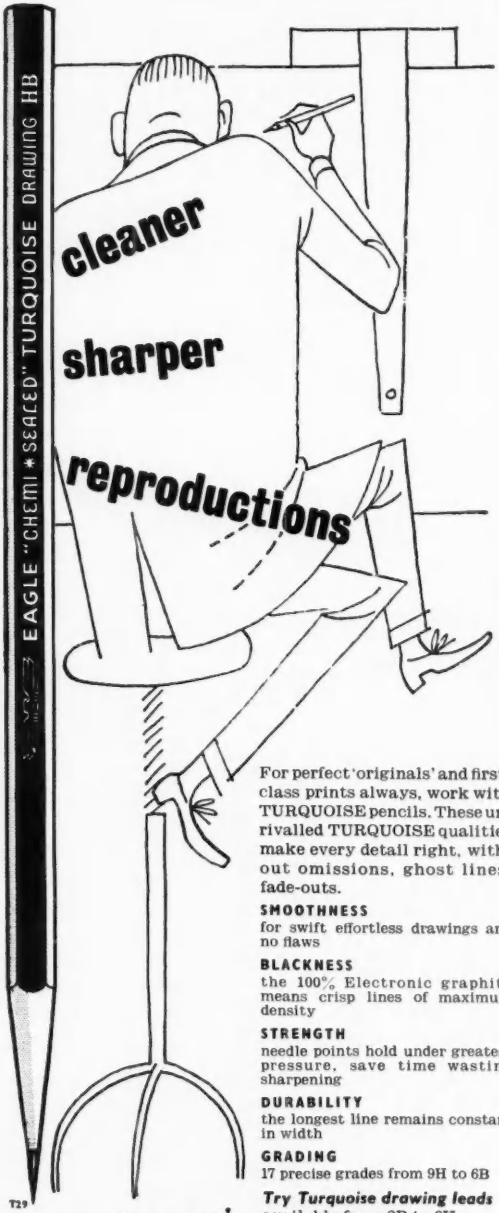

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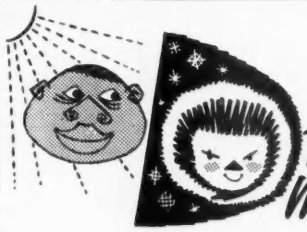

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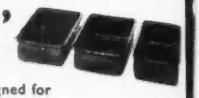

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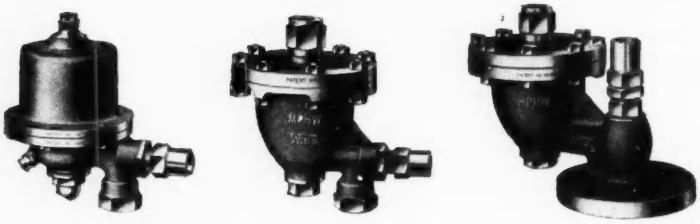

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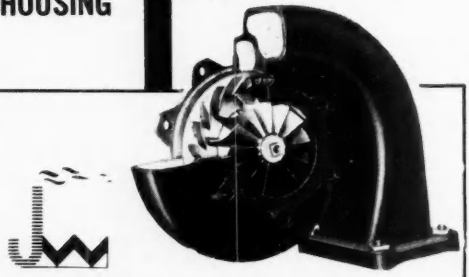

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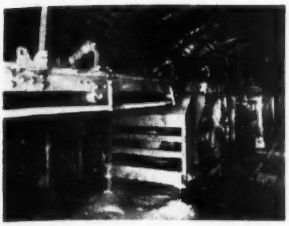

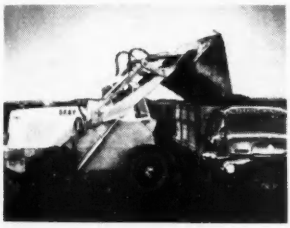

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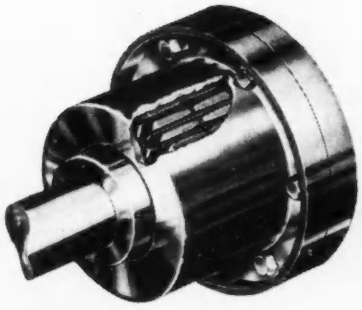

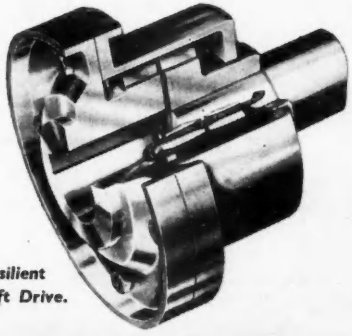

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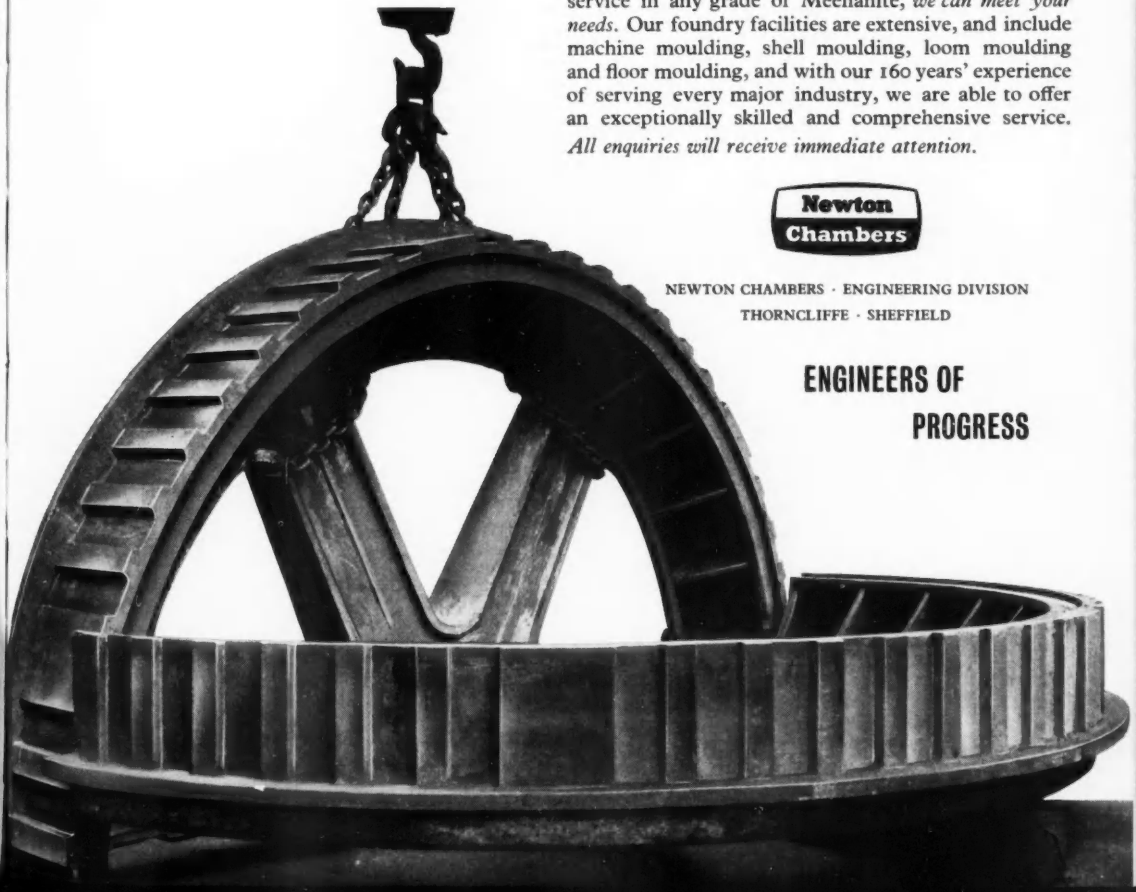

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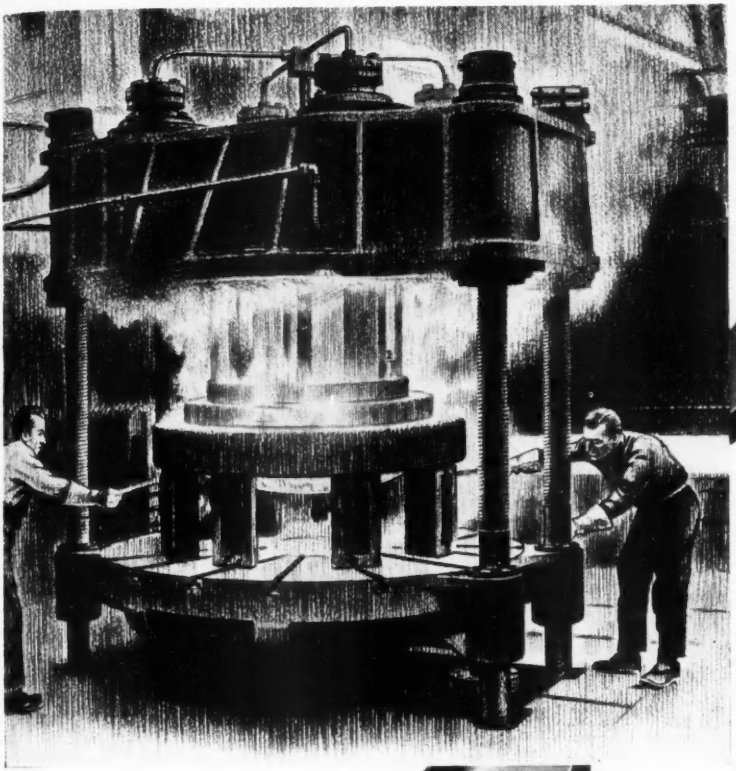

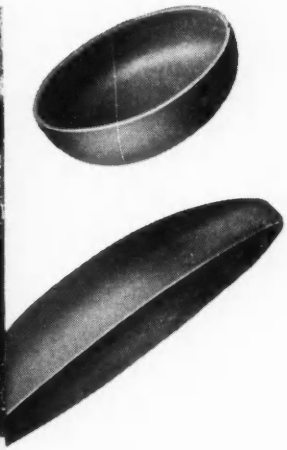

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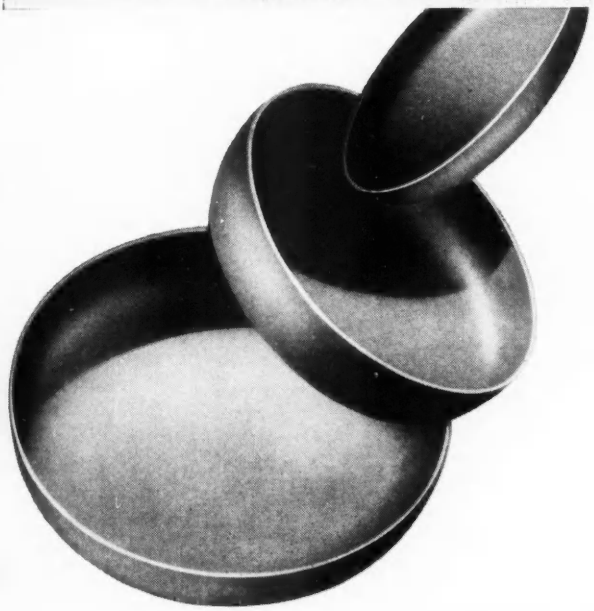

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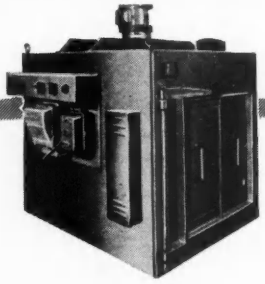

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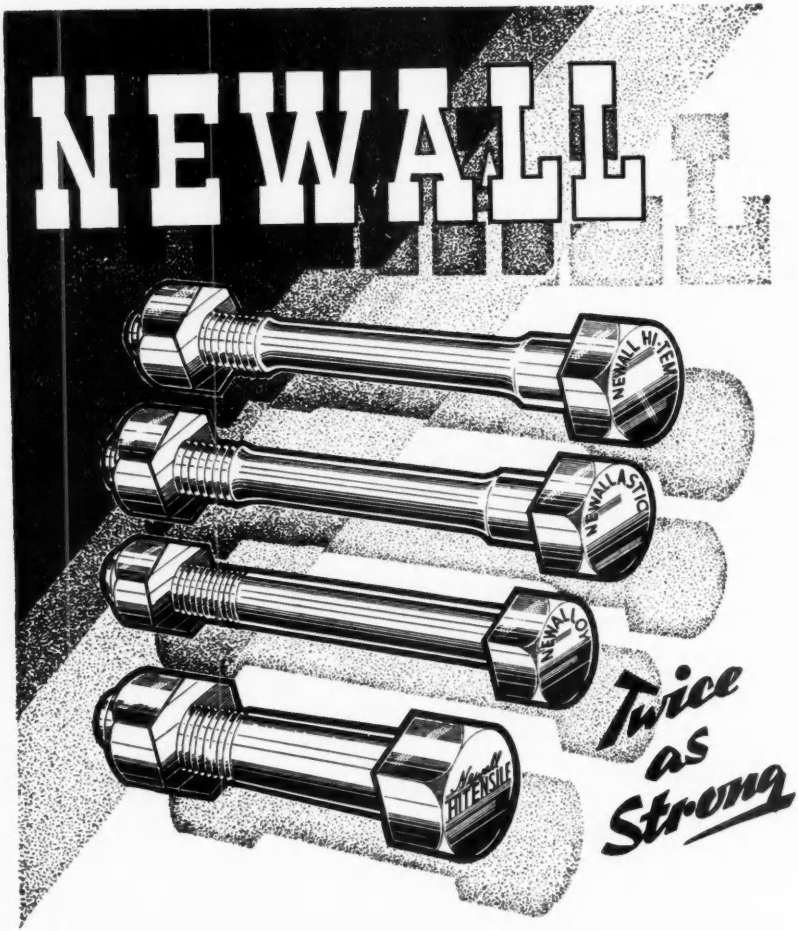

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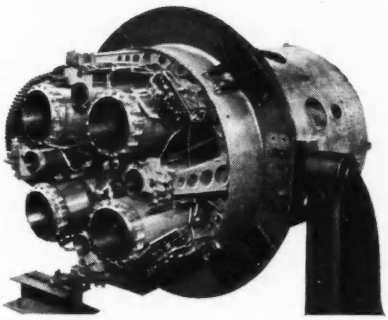

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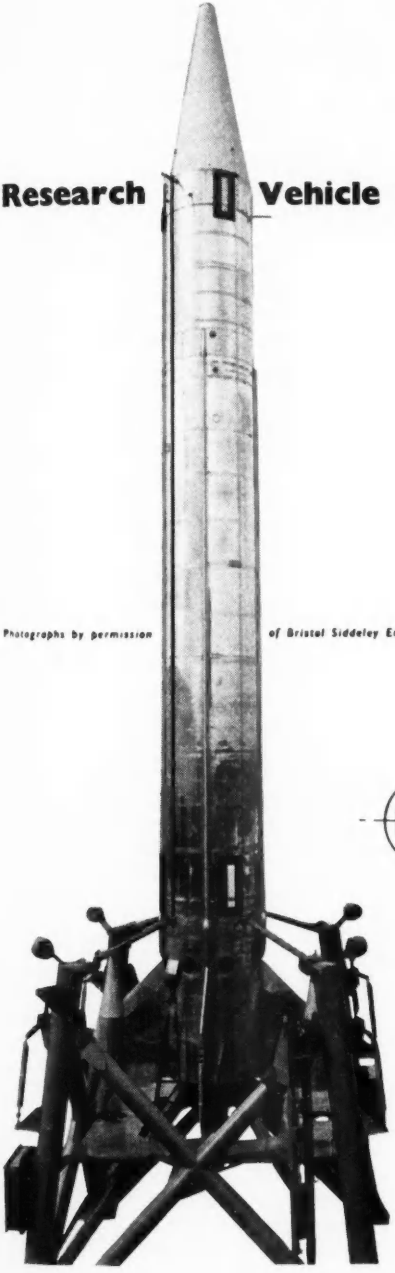

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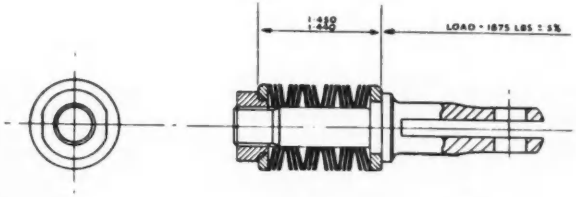

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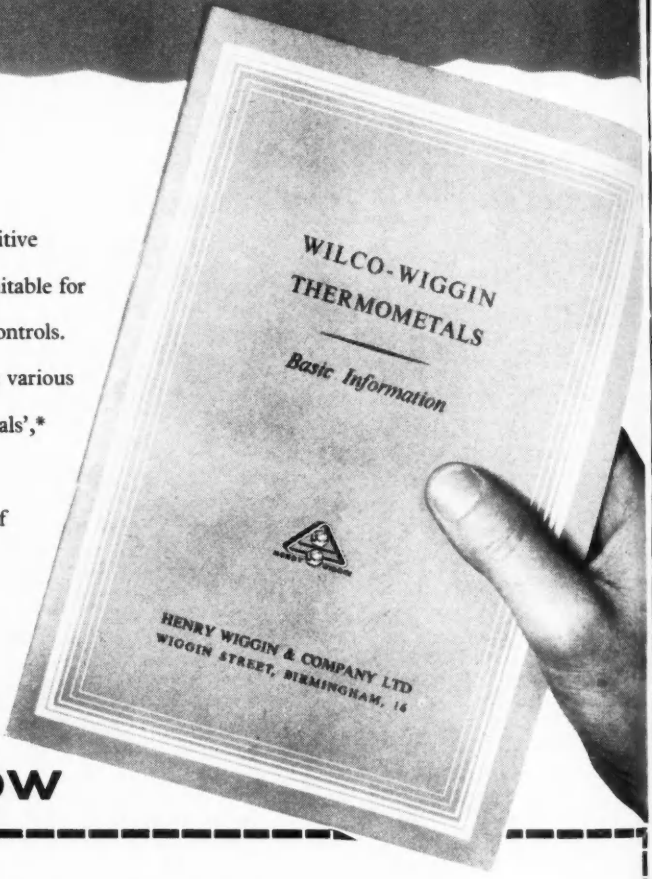

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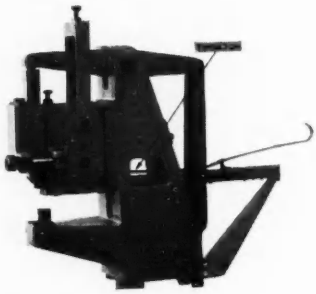

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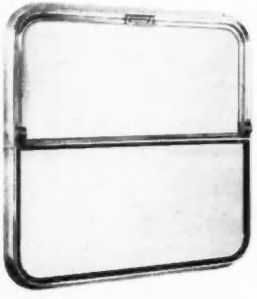

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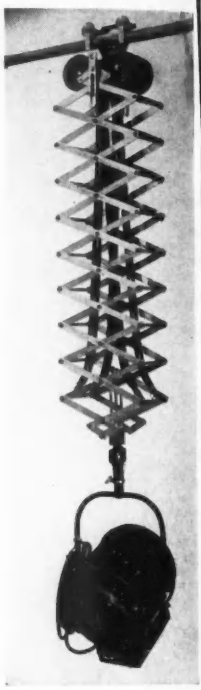

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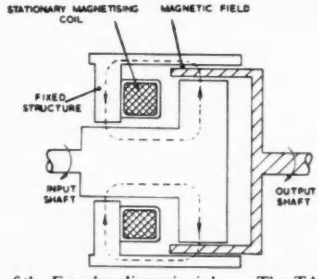

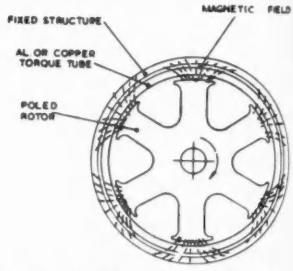

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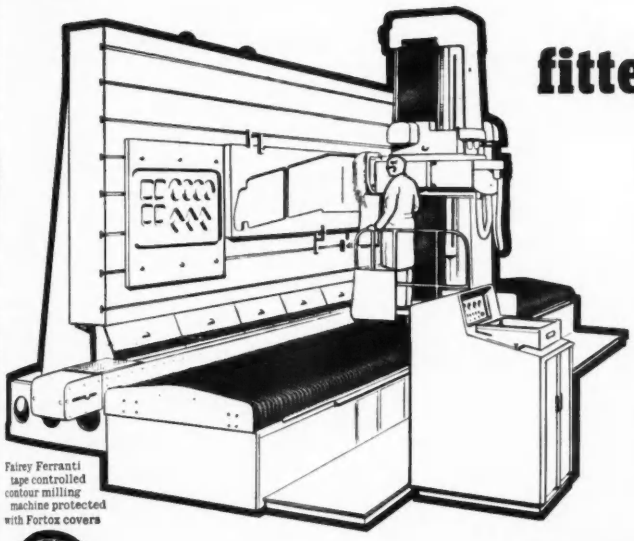

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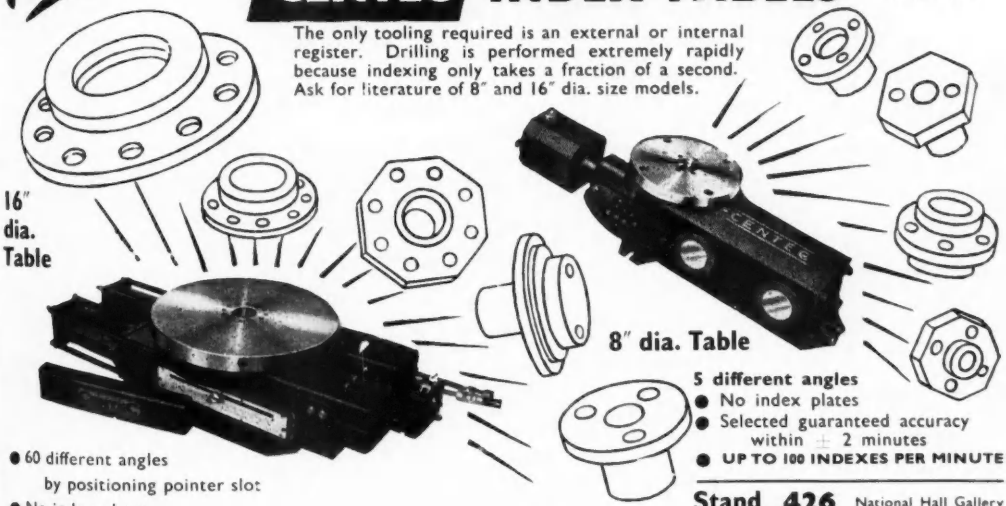

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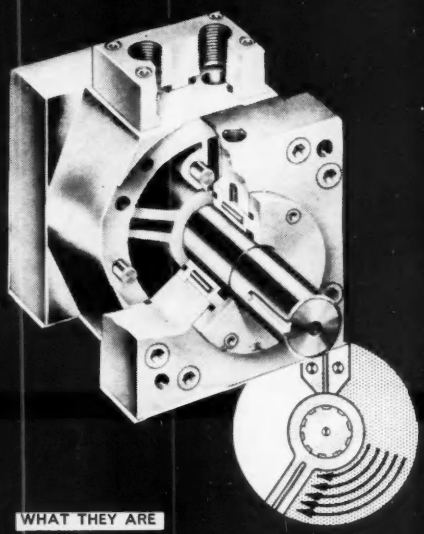

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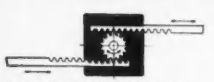

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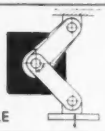

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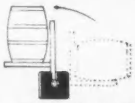

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Opening and closing doors.
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Crane boom operation.
Pipe and tube bending.
Fatigue test applications.
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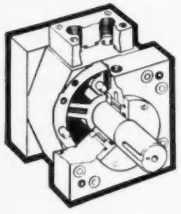

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